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MARINE BIOLOGY AT BEAUFORT.

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THE sandy strip of land which extends along the North Carolina coast, separating the ocean on one side from the system of sounds on the other, is interrupted at intervals. The breaks or inlets thus convert the strip into a series of long, narrow islands, known as banks. On the mainland, opposite the inlet between Shackelford and Bogue banks, is the town of Beaufort, some 350 miles south of Baltimore and 250 northeast of Charleston. The coast line here runs nearly east and west, and Beaufort is at the end of a little peninsula which juts out from the mainland toward the south, and is nearly surrounded by water. Beaufort inlet is a mile and a half in width, and it is about the same distance, in a straight line across the harbor, from the town to Fort Macon, at the extreme end of Bogue bank. The harbor occupies an area some four or five miles wide, passing to the east and west into the shallower waters of Back (opening into Core, thence into Pamlico) and Bogue sounds, respectively.

The harbor is diversified with numerous sand shoals, mud flats, salt marshes, all more or less submerged at high water;

at which time, with the centerboard up, a "sharpy" (the favorite form of sailboat, imported here from Connecticut) may be sailed in a straight line from the inlet to the town. Behind the protecting shoals the water is always quiet, so that one may go collecting in this part of the harbor in a skiff at times when the breakers are high in the inlet and running freely along the seaward edge of the shoals. The wealth of life buried in the sand shoals and mud flats is remarkable — every spadeful

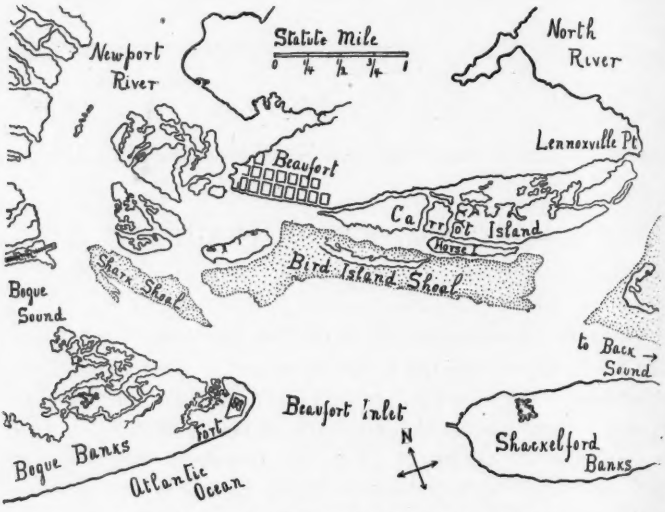


FIG. 1. — BEAUFORT HARBOR. After U. S. C. and G. S. Chart 420.

brings up something. Worms are of course best represented, although sea anemones, holothurians, spatangoid urchins, burrowing Crustacea, and mollusks abound. The natural absence of rocks over the bottom forces the sessile forms to make use of whatever will afford a foothold. Diopatra tubes become covered with ascidians, these with algæ, hydroids, polyzoa, and small tubicolous annelids. Algæ and sponges fasten on partially submerged shells. The oyster beds ("oyster rocks" in the local vernacular) distributed round the margin of the flats afford a home for many other attached mollusks, and for anemones and sponges, while crabs, gasteropods, nudibranchs, ophi-

urans crawl about over the shells, and burrowing shrimps bury themselves in the mud beneath and between them.

Passing from the shoals into the deeper water of the harbor channels, the bottom is found in places to be sandy, elsewhere muddy or covered with a shelly detritus. In many places one may collect with a long-handled scraping net, working from a skiff or sailboat. But for any extensive bottom collecting the dredge and trawl, with a steam launch, are necessary. Sponges, sea feathers and fans, the beautiful Renilla, Astrangia and rarely other corals, starfish, sea urchins, sand dollars, bottom-loving shrimps, crabs, mollusks are thus taken.

The sea bottom outside the inlet, within five or six miles off the coast, has been pretty well explored with dredge and trawl. Near shore, in many places, the bottom is a sticky mud, covered with sand dollars and with abundant medusæ (Chiropsalmus). A sandy bottom is more common. The slope is gradual, the depth at five miles from the beach line being, in general, eight to nine fathoms. Many forms which are commonly seen on the beach, cast up after a storm, grow in abundance in localities within the five-mile limit. Certain crabs (Persephona, Hepatus) and starfish (Astropecten, Luidia) may especially be mentioned as conspicuous examples. The beach collecting after a southerly blow is often good. Quantities of anemones (Paractis), holothurians, compound ascidians, sponges, and stranded jellyfish are to be had.

The wharf piles at Morehead City (railroad terminus) and Beaufort, and the stone jetties on each side of the inlet deserve to be mentioned. They are among the best collecting places for attached forms — algæ, hydroids, sponges, polyzoa, anemones. Beaufort is a capital place for the study of pelagic types. A strong tide sets into the harbor, bringing a great variety of hydromedusæ, Entomostraca, pelagic worms, and a wealth of larval forms. Certain interesting Protozoa (Acanthometra, Noctiluca) are very abundant. The proximity of the gulf stream (the 100-fathom line, which marks the western bank of the stream,[1] is some fifty miles distant) frequently leads to the presence in the harbor of many forms character-

[1] Agassiz. *Three Cruises of the "Blake,"* vol. i, p. 257.

istic of more southern waters. These forms often appear in large numbers, and many remain for weeks. Among such may be mentioned Physalia, Porpita (Professor Brooks mentions[1] that he has here taken nearly all the siphonophores known to occur on the Atlantic coast), the rhizostomous medusa Stomolophus, the pelagic annelid Amphinome. On a calm evening in Beaufort harbor, with a flood tide, it is best to abandon the tow net for the dip net. The individuals are abundant enough to make the use of the latter successful, and the perfect condition in which delicate forms, such as Diphyes, Lucifer, Cuninas, Phyllosoma larvæ, etc., may thus be taken repays for the time spent.

Beaufort itself is a quaint and attractive town, with its wide, grassy lanes, and inclining trees (live oaks, mulberries, elms), which show plainly the direction of the prevailing wind. Viewed from the harbor the town presents a long line of white houses that edge the shore, each with its upper and lower porch, from which (more especially the upper) the harbor in turn offers a very pleasing picture. In the late afternoon, when the glare has become less intense, the picture is one that stays in the memory as a restful composition of sky and water, the latter broken here and there with green marsh islands and white shoals, with sand dunes on the banks and breakers in the inlet shutting in the view. To the eastward big reels, on which seines are wound, make a detail suggestive of the village life.

The climate is equable, but cold comes occasionally, as in last February, when the fig trees were killed to the ground. The summer temperature is not unpleasant, though one's workroom should be a large, airy one close to the shore ("on the town front," as the saying is) and open to the sea breeze. I have before me a record of temperatures made by Professor E. A. Andrews during the warmer part of the year. The observations were taken at 7 A.M and 9 P.M. daily. During May the temperature at these times was, day after day, 74°–75°. In June there were some cold days, the thermometer going down to 66°, the weather growing warmer, though, in the latter part of the month, when 78°–79° was reached. Dur-

[1] *Report of the President of the Johns Hopkins University*, p. 82, 1883.

FIG. 2. — BEAUFORT — A PART OF THE "TOWN FRONT."

(The photographs made use of in the preparation of this article have been kindly loaned by Professor J. I. Hamaker.)

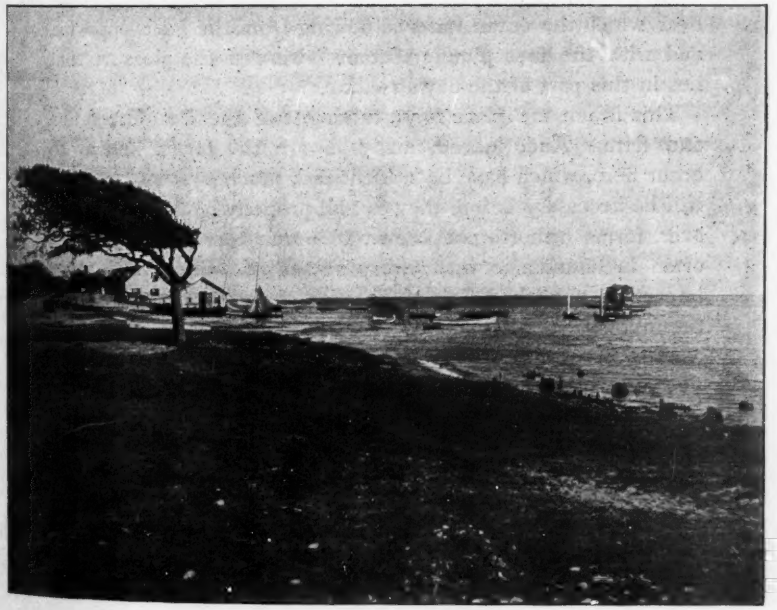


FIG. 3. — EAST END OF BEAUFORT — THE TOWN SHORE.

ing July and August the temperature on many days was 79°–81°, rarely going a degree or two above that, and much more frequently dropping several degrees below. In September the weather was cooler, the range being from 67° to 80°. At midday a very common summer temperature is 85° — only occasionally (at the times when 100°–105° is registered for so many of the cities) is it warmer. During the past season the laboratory was comfortable day and night, save once in June, when the heat of the lamps made microscopic work trying.

With proper precautions Beaufort is a healthful as well as a pleasant summering place for most people. Morehead City, across the harbor, is a well-known resort in this part of the South, and many people come also to Beaufort. The fishing, sailing, and the daily bath make the days pass agreeably for those who have nothing else to do, and contribute much to the *bien-être* of naturalists who are spending a working vacation. The ocean beach is a hard, fine one, and the surf bathing about like that of the better known Jersey coast. For the regular daily bath, however, most people prefer the harbor. With a skiff, in five minutes, one reaches a clean sand shoal, over which the ocean water is flowing from the inlet opposite, and with the first plunge becomes aware of the pleasure that lies in this part of the day's routine.

This is not the place for a catalogue of the Beaufort fauna and flora. And, indeed, many as are the forms known to occur here, which have been identified, much systematic work will be necessary before they can all properly be listed. Moreover, forms hitherto not known to occur here are discovered often in abundance with every season of work. The more important published lists of Beaufort forms are contained in the following papers:

Wm. Stimpson, M.D. "A Trip to Beaufort, N. C.," *Amer. Journ. of Sci.*, Series 2, Vol. XXIX, 1860. The paper contains lists of ascidians, mollusks, and decapod Crustacea. The Lingula of the south Atlantic coast is here first described, although McCrady, writing shortly after from Charleston (*Amer. Journ. Sci.*, Vol. XXX), mentions that it "was found more than ten years ago on our coast by the Rev. Thomas J.

Young," and that Professor Louis Agassiz, at his laboratory in Charleston harbor, had had specimens. McCrady was, I believe, the first to observe Lingula larvæ, since described in Professor Brooks's well-known paper and taken in Beaufort harbor, both by Professor Brooks and (during the past season) by Professor J. Y. Graham.

Coues and Yarrow, "Notes on the Natural History of Fort Macon, North Carolina, and Vicinity" (Nos. 1–3), *Proc. Acad. Nat. Sci. Phila.*, 1871, 1877. The vertebrate lists are much more complete than the invertebrate. There are recorded 24 mammals, 133 birds, 27 reptiles, 6 amphibia, 111 fishes. Of the invertebrates recorded the only list approaching completeness is that of the mollusks (147).

A. E. Verrill, "On Radiata from the Coast of North Carolina," *Amer. Journ. Sci.*, 1872. This paper includes lists of cœlenterates and echinoderms (Coues and Yarrow's Collection).

A. E. Verrill, "Notes on Natural History of Fort Macon" (Coues and Yarrow's Collection of Annelids), *Proc. Acad. Nat. Sci. Phila.*, 1878.

J. S. Kingsley, "On a Collection of Crustacea from Virginia, North Carolina, and Florida," etc., *Proc. Acad. Nat. Sci. Phila.*, 1879.

J. S. Kingsley, "List of Decapod Crustacea of the Atlantic Coast," whose range embraces Fort Macon, *Proc. Acad. Nat. Sci. Phila.*, 1878.

In these two papers of Kingsley's there are recorded over sixty decapods for Beaufort harbor.

Jordan and Gilbert, "Notes on Fishes of Beaufort Harbor, North Carolina," *Proc. U. S. Nat. Mus.*, 1878.

E. A. Andrews, "Report upon the Annelida polychæta of Beaufort, North Carolina," *Proc. U. S. Nat. Mus.*, Vol. XIV, 1891.

Many of the Beaufort forms have been first described by some of the older naturalists, whose collections were made farther south, along the coasts of South Carolina, Georgia, and Florida. Among such may be especially mentioned Catesby[1],

[1] Natural History of Carolina, Florida, and the Bahama Islands.

Bosc[1], Say[2], Le Sueur[3], Louis Agassiz[4], Gibbes[5], Stimpson[6], McCrady[7]. Other forms are constantly met with, which were first described by naturalists working farther north, on the Virginian coast (H. E. Webster)[8], on the coasts of Rhode Island and New Jersey (Leidy)[9], coast of New York (De Kay)[10], New England coast (Verrill[11], Verrill and Smith[12], Gould and Binney[13]). Other well-known memoirs, which are especially useful for systematic work at Beaufort are: Alexander Agassiz's "North American Acalephæ"[14]; Verrill's "Revision of the Polypi of the Eastern Coast of the United States"[15]; the various reports on the results of dredging, under the supervision of Alexander Agassiz, by the U. S. Coast Survey Steamer *Blake* (published in the *Memoirs* and *Bulletin* of the Museum of Comparative Zoölogy); Dall's "Catalogue of Mollusks and Brachiopods of Southeastern Coast of United States."[16]

In the *Studies from the Biological Laboratory of the Johns*

[1] Hist. Nat. des Crustacés; Hist. Nat. des Vers.

[2] An Account of the Crustacea of the United States, *Journ. Acad. Nat. Sci. Phila.*, vol. i, 1817–18, *The Complete Writings of Thomas Say on the Conchology of the United States*, edited by Wm. G. Binney, 1858.

[3] Observations on Several Species of the Genus Actinia, *Journ. Acad. Nat. Sci. Phila.*, vol. i, 1817–18.

[4] Contributions to the Natural History of the United States.

[5] On the Carcinological Collections of the United States, and descriptions of new species, *Proc. Amer. Ass. Adv. Sci.*, vol. iii, 1850.

[6] Notes on North American Crustacea, *Ann. Lyceum Nat. Hist. of N. Y.*, vol. vii, 1862. On Some Remarkable Marine Invertebrates inhabiting the Shores of South Carolina, *Proc. Bost. Soc. Nat. Hist.*, vol. v, 1856.

[7] Gymnophthalmata of Charleston Harbor, *Proc. Elliott Soc. Charleston*, vol. i, 1853–58.

[8] Annelida chætopoda of the Virginian Coast.

[9] Marine Invertebrate Fauna of Coasts of Rhode Island and New Jersey, *Journ. Acad. Sci. Phila.*, vol. iii, 1855.

[10] *The Natural History of New York*, Pt. i, Zoölogy. The volume on Mollusca and Crustacea is particularly useful to the collector, because of its condensed descriptions of "extra limital" forms.

[11] *New England Annelida*, Pt. i, 1881.

[12] *Report on Invertebrate Animals of Vineyard Sound*, 1873.

[13] *Report on the Invertebrata of Massachusetts*, 2d ed.

[14] *Illust. Cat. of Mus. of Comp. Zoölogy*, 1865.

[15] *Mem. Bost. Soc. Nat. Hist.*, vol. i, 1866–69.

[16] *Bull. U. S. Nat. Mus.*, *No. 37*, 1889.

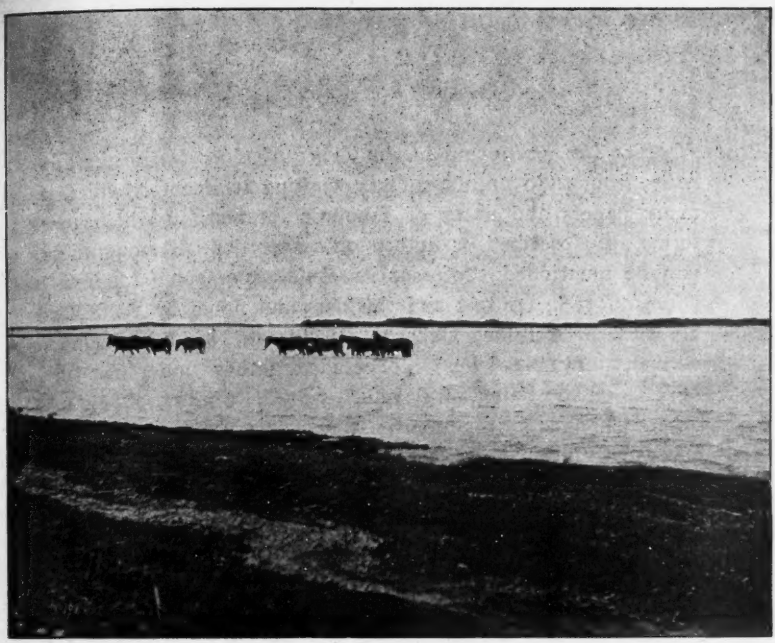


FIG. 4. — TO THE EAST OF BEAUFORT — SHACKELFORD BANK IN THE DISTANCE.

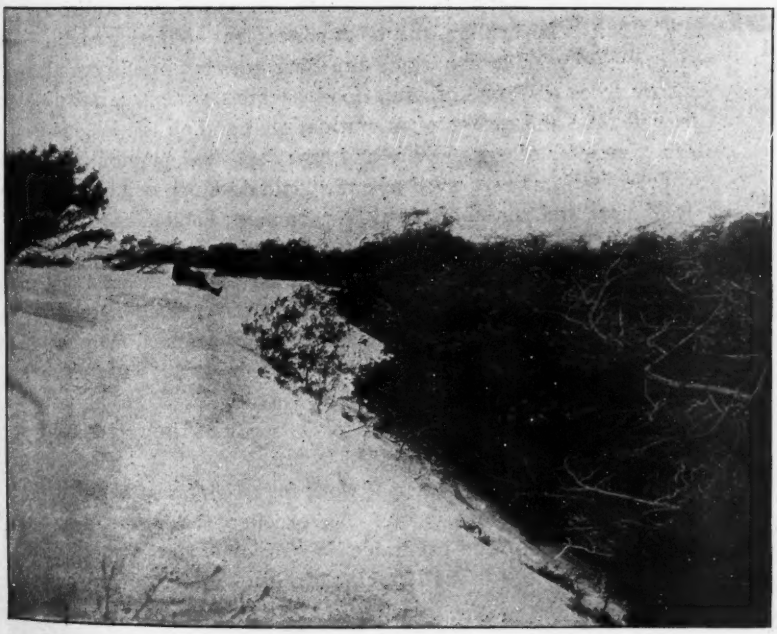


FIG. 5. — SAND DUNE ON SHACKELFORD BANK.

Hopkins University, and in the *Johns Hopkins University Circular*, from 1880 on, naturalists working at Beaufort will find many papers and notes of faunistic interest, in which new forms are described or known ones recorded. Among these may be mentioned Professor Brooks's papers on "Medusæ" (*Studies*, 1882, 1883); and the lists and notes by Professors McMurrich (Actiniæ), Osborne (Mollusca), Nachtrieb (echinoderms), Jenkins (fishes), collected together under the title "Notes on the Fauna of Beaufort, N. C." (*Studies*, 1887). A great many facts of general natural history interest (systematic, distributional, ecological) will also be found scattered through the pages of the morphological and embryological memoirs which have been appearing since 1880 as the result of the work of Professor Brooks and his students at Beaufort.

At the laboratory of the U. S. Fish Commission, which was maintained during the past summer at Beaufort, the various species observed were recorded, and specimens preserved for the museum collection of the laboratory. It is planned that the record of each species shall include mention of the localities in which it is fairly abundant, most convenient collecting methods, time of year during which breeding goes on, brief natural history notes on habits of adult (food, enemies, parasites, rate of growth, time and extent of migration, etc.) and on the life history (character of eggs, where and how deposited, possibility of artificial fertilization, period of embryonic development, character of larva and period of larval development, habitat, food and enemies of larva). The economic value of such a knowledge of the natural history of the region will be readily understood, and it is equally obvious to what an extent it will aid naturalists engaged in the study of the abstruse problems of morphological and physiological embryology, of comparative anatomy and physiology. Its value in connection with similar results of the work at other coast stations, to the study of the variability of organisms, may be here alluded to.

To carry out such a scheme of work for a rich fauna like that of Beaufort will require years. An excellent basis has, however, been built up, and profitable lines of study marked out by the members of the Johns Hopkins Marine Laboratory and by

other naturalists. During the past season's work (1899) of the Fish Commission Laboratory many of the previously known facts, some recorded, some unrecorded (in the possession of former workers at Beaufort), have been brought together and confirmed, and important additions have been made. The forms actually collected during the season included 238 species of marine invertebrates, some 70 fishes, 50 birds, a number of reptiles, amphibia, insects and arachnoids, and a very considerable number of land plants and algæ. In the case of a good number of species, notes along the lines indicated above were made. In gathering the data of the record all members of the laboratory lent their assistance, during such time as they were able to spare from their special investigations. I would especially thank Professors W. K. Brooks, E. W. Berger, J. Y. Graham, J. I. Hamaker, T. G. Pearson, Dr. D. S. Johnson, Dr. G. A. Drew, and Dr. Caswell Grave. Identifications and notes on breeding times have also been very kindly contributed by Professors E. A. Andrews, C. B. Davenport, J. S. Kingsley, George Lefevre, M. M. Metcalf, J. P. McMurrich, E. B. Wilson. In another season's work, doubtless, all the recorded forms will have been taken and identified. Further progress can only be made by a formal division of labor among the members of the laboratory. With the great awakening of interest, which is so apparent to-day, in the phenomena exhibited by animals and plants regarded as living units, it should not be difficult to find naturalists who will gladly work up the local natural history of the groups embracing the particular forms on which they may be investigating problems of a morphological or physiological character.

From among the forms occurring at Beaufort the following common summer ones may be selected with the purpose of giving a conspectus of the local fauna and flora. The months given immediately after the name of each species are breeding months, but it is not implied that breeding is limited to these months. In many forms breeding undoubtedly continues through a large part of the year — oyster eggs, for instance, have been fertilized in December by Dr. Caswell Grave. With a few exceptions the forms listed were noted during the past

season. The exceptions include forms recorded by myself in 1886, 1894, 1898.

Protozoa. — *Noctiluca miliaris* and Acanthometra *sp.* are abundant in the tow throughout summer.

Sponges. — *Chalina arbuscula, Microciona prolifera, Cliona sulphurea,* and several other monactinellid sponges are common. No eggs nor gemmules have been observed during the earlier summer months, but by September 1st a number of species are breeding.

Cœlenterates.

Hydrozoa. — Hydroids: *Hydractinia echinata,* with gonophores, June; *Eudendrium ramosum,* with gonophores, June; *Sertularia carolinensis* (*sp.*?), with gonothecæ, June; *Aglaophenia trifida;* Campanularia *sp.; Parypha cristata,* with gonophores, June, July. Hydromedusæ: *Liriope scutigera,* July, August; *Nemopsis bachei,* July, August; *Cunoctantha octonaria,* adults and parasitic larvæ, July, August; Cunina *sp.,* parasitic larvæ in Liriope, August; *Turritopsis nutricula,* July, August; *Margelis carolinensis; Eutima mira.* Siphonophores: Diphyes *sp., Physalia arethusa, Porpita linnæana.*

Scyphomedusæ. — *Stomolophus meleagris, Chiropsalmus quadrumanus, Dactylometra quinquecirra, Cyanea versicolor* (*sp.*?). Ephyra larvæ (*sp.*?), common in tow, July, August.

Actiniaria and Madreporaria. — *Paractis rapiformis, Aulactinia capitata, Adamsia sol, Aiptasia pallida, Cerianthus americanus, Astrangia danæ,* Oculina *sp.* Arachnactis larvæ, in tow, August.

Alcyonaria. — *Renilla reniformis,* May, June, July; *Leptogorgia virgulata,* May, June, July; *Rhipidogorgia flabellum.*

Ctenophora. — *Mnemiopsis gardeni.*

Echinoderms. — Starfishes: *Asterias arenicola,* April; *Luidia clathrata,* August; *Astropecten articulatus,* August; large bipinnariæ with budding starfish in tow, July. Ophiuroids: Amphiura *sp.,* June, larva a pluteus (species dredged three to nine fathoms, outside inlet); *Ophiura brevispina,* July, August, eggs discharged shortly after nightfall; *Ophiothrix angulata* (*sp.*?), June, July; *Ophiolepis elegans,* nine fathoms, outside inlet, eggs nearly mature July 12. Echinoids: *Arbacia punctulata,*

June, July; *Toxopneustes variegatus*, June, July; *Moira atropos*, August; *Mellita testudinata*, early September. Holothurians: Thyone briareus; *Leptosynapta girardii* (*sp.?*), with apparently mature eggs, July; small synaptas abundant in night tow, August.

Worms. — Annelids: *Amphitrite ornata*, June; *Petaloproctus socialis;* Notomastus *sp.*; *Marphysa sanguinea; Diopatra cuprea; D. magna*, egg mass containing larvæ, July; *Nereis limbata*, September; *Hydroides dianthus*, July; *Harmothoe aculeata; Axiothea mucosa*, June, July; *Arabella opalina; Loimia turgida; Arenicola cristata*, June to August; *Sabella microphthalma; Pectinaria gouldii; Sabellaria vulgaris*, July; *Autolytus cornutus*, August, September (in tow); *Proceræa ornata; P. tardigrada*, early September (night tow); *Rhyncobolus americanus; Chætopterus pergamentaceus*, June to August; *Sthenalais picta.* The interesting pelagic form, *Amphinome pallasii* (one of the *Blake* species), appeared in the harbor July 18; eggs and sperm were freely discharged. Other "worms": *Bdelloura candida*, June; *Meckelia rosea* (*sp.?*); *Cerebratulus ingens;* Sagitta *sp.*, June to September; *Thalassema mellita*, June; *Balanoglossus brooksii, B. kowalevskii* (*sp.?*). Professor Andrews in 1885 discovered the presence of the interesting form Phoronis (*P. architecta* Andr.). Actinotrocha larvæ are common in the tow during summer.

Mollusca. — In Stimpson's list (*loc. cit.*, 1860) 174 mollusks are recorded. Coues and Yarrow (*loc. cit.*) again list most of these and record a few others. Osborn (*loc. cit.*) records still others. The following may be mentioned:

Lamellibranchs: *Venus rugosa* (*sp.?*) June, the burrowing form *Lithodomus lithophagus, Cytherea gigantea, Dosinia discus, Moctra solidissima, Tagelus gibbus, T. divisus, Modiola plicatula*, Pholas *sp.* (small species found in rotten wood; shells of *P. costata* common), *Solenomya vetum, Anomia glabra, Arca transversa, A. ponderosa, A. pexata, Cyclas dentata, Cardium magnum, Pecten dislocatus, Donax fossor, Tellina alternata, Ostrea virginiana, Xylotria fimbriata* (and other shipworms) August, *Pinna semi-nuda*, Lima *sp.*, *Venus mercenaria, Rocellaria stimpsoni.*

Gastropods. — *Fulgur carica*, June, July; *F. canaliculata*; *Neverita duplicata*, June, July; *Sigaretus perspectivus*; *Purpura hæmastoma*, eggs deposited in confinement, July; *Strombus alatus*; *Fasciolaria tulipa*, June, July; *Crepidula fornicata*, June; *C. plana*, June; *Ilyonassa obsoleta*; *Urosalpinx cinerea*, June; *Oliva literata*; *Ovulum uniplicatum*; *Fissurella alternata*; *Littorina irrorata*; *Chætopleura apiculata*.

Among the opisthobranchs, species of Aphysia, Æolis, Doris, Polycera, Scyllæa (on gulf weed), Ancula, occur. Among the pteropods, *Styliola vitrea* is occasionally abundant. Among the cephalopods, *Loligo pealii* is rarely taken, and a form of lighter color (*sp.*?) more commonly. Squid eggs are frequently dredged during summer, outside the inlet.

Crustacea. — As has been mentioned, something over sixty decapods are recorded for the locality. Beaufort is far enough to the south for the crab fauna, in particular, to show something of that variety, which becomes so pronounced in the tropics.

Decapods. — *Panopeus herbstii*, June, July; *Lupa sayi*, July; *Sesarma reticulata*; *Menippe mercenaria* ("stone crab"); *Callinectes hastatus*, June; *Ocypoda arenaria*; *Libinia canaliculata*; *Hepatus decorus*; *Gelasimus pugnax*; *Persephona punctata*, September; *Platyonichus ocellatus*; *Porcellana ocellata*, September; *P. macrocheles*, July, August (commensal in Chætopterus tubes); *Pinnotheres ostreum*; *Pinnixa chætopterana*, August (a rarer commensal in Chætopterus tubes); *Hippa emerita*; *Eupagurus vittatus*, June; *E. longicarpus*; *E. pollicaris*; *Penæus setiferus* (sold during latter part of August and September); *Palæmonetes vulgaris*, July; *Alpheus heterochelis*, July to September; *Alpheus minus*, September; *Gebia affinis*, June; *Tozeuma carolinensis*, August; Lucifer *sp.*, summer. The taking of the curious "false hermit" (*Hypoconcha arcuata*) may be referred to—the form has been recorded by Stimpson from South Carolina.

Among the forms belonging to other groups of Crustacea may be mentioned: *Squilla empusa*, *Lysiosquilla excavatrix*, Diastylis *sp.* (this cumacean is regularly taken in the night tow throughout summer); a large isopod (Ligia *sp.*), very abundant

on wharves; an isopod (Gyge *sp.*), parasitic in branchial cavity of *Alpheus heterochelis;* another parasitic isopod (*Livoneca ovalis*, with embryos in August), common on gills of pinfish; Orchestia *sp.*; Caprella *sp.*, June. Numerous copepods and cladocera, many with eggs or embryos, are constantly taken in the tow throughout summer.

Among the cirripeds may be mentioned the common rock barnacle and ivory barnacle (*Balanus eburneus*), *Lepas anatifera*, which frequently appears in the harbor; a small Lepadide (Dichelaspis *sp.*), a common parasitic form on the gills of the edible crab, with abundant eggs in July, — this interesting form is probably the species mentioned by Fritz Müller (*Facts for Darwin*, p. 137) as occurring at Desterro on same crab (*Lupa diacantha*), — it differs in specific points from the several other members of the genus, described by Darwin and Hoek (*Challenger* Report). Limulus is of course abundant, young specimens swarming on the sand shoals in early summer (June). The eggs of Limulus were, as far as I know, for the first time artificially fertilized in 1882 by Professor H. L. Osborn at Professor Brooks's laboratory here.

Naturally but little attention has been paid to the tracheate arthropods — enough though to show that the locality is an excellent one for these groups. A few characteristic forms are: the slender, long-legged myriapod *Cermatia forceps*, sphinx moth, *Phlegethontius carolina* (larva, "tomato-worm," excellent for anatomical work and for metamorphosis), rhinoceros beetle, *Dynastes tityrus*. One of the large hunting spiders, Lysosa *sp.* (carrying cocoon in early September), is abundant. The cow-killer ant (burrowing mutillid wasp, female wingless), *Sphærophthalma sp.*, is a common form.

The polyzoa have not been studied. The common forms are species of Vesicularia, Bugula, Membranipora, Escharella, Pedicellina (species with spines, probably *P. echinata*). The only brachiopod known here, *Lingula pyramidata*, and its larva have already been spoken of. The particular locality in the harbor (first mentioned by Coues, *loc. cit.*) where Lingula, associated with Renilla and Amphioxus, was extremely abundant some years ago, has been encroached upon by a growing

shoal and is no longer a good collecting place. Some equally good spots may in time be located.

The tunicates, too, are badly in need of systematic work. A large ascidian, Styela *sp.* (doubtless the *Cynthia vittata* of Stimpson's list), two to three inches high, is extremely abundant on the sand shoals and wharf piles. Another large and translucent form, Ascidia *sp.*, is fairly abundant on wharf piles and old shells, breeding in May and June. *Molgula manhattensis*, *Perophora viridis* (breeding in June and July), Amarœcium *sp.* are common species. Appendicularia *sp.* is a common form in the tow throughout summer — Professor George Lefevre has found it breeding from April to August. Doliolum *sp.* is occasionally taken in the harbor through the summer — both the nurse with stolon and buds, and the sexual form with ripe eggs.

The variety of fishes that may be taken in a short time in Beaufort harbor and adjoining waters is so great as to make it evident that the number recorded (Jenkins, *loc. cit.*, gives 134) for the region will be greatly increased when systematic collecting has been carried on for a few years. Some nine miles from Beaufort inlet the coast line makes a sharp, right-angled bend, with Cape Lookout at the angle. From the end of the cape a narrow line of shoals extends much farther out. The cape and its submerged continuation form a wall, as it were, reaching seaward for fifteen miles. Cape Lookout itself is so shaped as to embrace a bay, a quiet and beautiful sheet of water, Lookout Bight. The coast configuration thus forms a remarkable natural trap into which fish, migrating northwards, fall. It is doubtful whether a better place can be found anywhere on our coast for the carrying out of observations on oceanic species and on bay and river species during the oceanic period of their life. The seining that has been carried on at Cape Lookout has been extremely interesting and successful, both as regards the variety of forms and the number of individuals taken.

The following species may be mentioned from the harbor and adjacent waters: Amphioxus is found, but is not common — the pelagic larvæ are taken in the tow (July). The com-

monest sharks are the "sharp-nosed," *Carcharinus terræ-novæ*, "shovel-headed," *Sphyrna tiburo*. Young "hammerheads," *Sphyrna zygæna*, are very abundant in the early summer in some years. The sawfish, *Pristis pectinatus*, is frequently taken. The sting ray, *Trygon sayi*, and butterfly skate, *Pteroplatea maclura*, are abundant. Several eagle rays are occasionally taken (cow-nosed ray, *Rhinoptera quadriloba*, last summer), and the sea devil, *Manta birostris*, has been caught at Cape Lookout. Several cyprinodons (Fundulus, Cyprinodon, Gambusia) are abundant alongshore and in "salt ponds" — *F. heteroclitus*, with ripe eggs, July. Blennies are abundant about the wharf piles, *Hypleurochilus multifilis* depositing its eggs on sponges, etc., August. The toadfish, *Batrachus tau*, and its eggs (summer) are of course abundant. *Selene vomer* and some other "moonfishes," two halfbeaks (*Hemirhamphus braziliensis*, *H. unifasciatus*), the shark pilot, *Echeneis naucrates*, pipefish, *Siphostoma floridæ*, and *Hippocampus hudsonius*, *Nomeus gronovii* (in bell cavity of the rhizostomous medusa, Stomolophus), several swellfishes (*Logocephalus lævigatus*, *Chilomycterus geometricus*, *Tetrodon turgidus*) may be referred to. The commonest summer food fishes are the bluefish, Spanish mackerel, sheepshead, jumping mullet, sea mullet, hogfish (*Orthopristis chrysopterus*), pinfish (*Diplodus rhomboides*), croaker, spot, porgee, weakfishes (local "trouts," *Cynoscion regale*, *C. maculatum*), "blackfish" (*Serranus atrarius*), a number of flounders (flounder spearing with a torch of "fat" pine is a common occupation on summer nights). The menhaden (local "fatback") fishery is an important industry. Some attention was paid during the past season to the breeding condition of the edible species, and June would seem to be a good month for fish-cultural work — the hogfish, porgee, and sea mullet are breeding at that time.

Birds. — The laboratory is indebted to Professor T. G. Pearson, of Guilford College, for the identification of some fifty summer birds. Gulls and terns are uncommon in the harbor. In the salt marshes several herons are abundant, also the clapper rail and the marsh wren (Worthington's), the interesting false nests of which are easily found. The Florida

cormorant is frequently seen flying across the harbor. Characteristic shorebirds are the black-bellied plover, oyster catcher, willet, spotted sandpiper, yellow legs. Other characteristic birds seen about the harbor are the fish crow and boat-tailed grackle. In the town, and in the woods back of the town, and on the banks, many species are found which are common in the central part of the state (mourning dove, flicker, kingbird, crested flycatcher, phœbe, towhee, cardinal, mocking bird, brown thrasher, titmouse, Carolina chickadee). In the winter there is said to be good duck shooting in the neighborhood of the town.

Other Vertebrates. — A number of lizards are abundant in and back of the town (*Anolis carolinensis*, *Eumeces fasciatus*, *Cnemidophorus sexlineatus*, *Sceloporus undulatus*). Alligators are said to be common in localities close to Beaufort, especially in White Oak River, opening into Bogue Sound. Specimens are occasionally brought into Beaufort. The bank ponies quickly attract the attention of the newcomer. They run wild on the banks and adjacent parts of the mainland, and are periodically corralled ("penned") for branding and sale. The ponies are fond of the salt-marsh grass, and droves may, on almost any day, be seen wading or swimming between the shore and the marsh islands. Deer are fairly abundant in localities, both on mainland and banks. Other common mammals are the mink, raccoon, opossum. Coues (*loc. cit.*) says the "marsh hare" (*Lepus palustris*) is "the most abundant and characteristic mammal" on Bogue bank. Porpoises are frequently seen in the harbor; the pairing season, according to Coues, is in April and May.

Dr. D. S. Johnson and Mr. W. C. Coker, of Johns Hopkins University, made, during the past season, a reconnaissance of the flora of the region, the results of which Dr. Johnson has embodied in two papers (on the flora of the banks, and the algæ of the harbor), which will appear in the Fish Commission publications. Dr. Johnson describes the peculiar physiographic characteristics of the banks, which (I quote from his unpublished paper) "vary in width from a quarter of a mile to a mile and a half, and in height from nearly sea-level, in the case of

certain fresh water and salt marshes, to a maximum height of perhaps forty feet in the case of some of the wind-blown dunes. The conditions prevailing on the higher parts of these banks are quite peculiar, in that while the shifting sandy soil holds very little water, yet the air is very damp, since during the growing season the prevailing wind is a strong sea breeze saturated with moisture. Thus are to be explained, perhaps, the frequent occurrence in this very dry soil of many plants which usually occupy a much damper soil, and the striking abundance of epiphytic lichens, liverworts, mosses, and ferns." While the algal flora is not so varied as on more rocky parts of the coast, a very considerable number of species are present in abundance. Among these may be mentioned *Hypnea musciformis, Ulva lactuca, Dictyota dichotoma, Rhabdonia tenera, Gracilaria confervoides, Codium tomentosum, Padina pavonia, Sargassum vulgare, Dasya elegans, Melobesia pustulata,* and species of Callithamnion, Ectocarpus, Enteromorpha, and Polysiphonia.

With its rich and accessible fauna it is not to be wondered at that Beaufort should have been so attractive to naturalists. Among those who carried on investigations in this locality before 1880 may be mentioned Professor Louis Agassiz, Dr. Stimpson, Dr. Gill, Dr. Coues, Dr. Yarrow, President Jordan, Professor Morse, Professor Packard, Professor Webster. In 1880 the marine laboratory of the Johns Hopkins University, which during the previous two years had been located at points in the Chesapeake Bay, was stationed here. A large house near the extreme eastern end of the town was rented continuously, and an excellent equipment, including a 47-foot sloop and a steam launch, was provided. Professor Brooks, with his students and co-workers, continued their investigations year after year at Beaufort (with the exception of 1883, when the laboratory was stationed at Hampton, Va.) until 1886, when they spent the summer in the Bahama Islands. During most of the years since that time the Johns Hopkins laboratory has been stationed in the Bahamas or in Jamaica, with returns to Beaufort at intervals. The important share which this laboratory has had, since its inauguration in 1878 at Fort Wool, in

determining the character of zoölogical study in America is well known. A list of its members will be found to include many of the leaders in this branch of science in the several parts of the country, and the number of memoirs and papers based on observations made during its sessions is very large.

During the last few years there have been in Beaufort, from time to time, parties of naturalists from Columbia (under Professor E. B. Wilson) and other universities, as well as from the Johns Hopkins. The U. S. Fish Commission has for years been familiar with the fact that Beaufort presented many opportunities for the scientific study of economic problems. The large number of edible fish and Crustacea, the extensive beds of clams and oysters, make the region one of commercial importance. At Professor Brooks's laboratory many contributions to the life histories of edible forms (shrimps, crabs, fish, oyster) were made. As a continuation, along economic lines, of Professor Brooks's discoveries concerning the development of the American oyster, Lieutenant Winslow's experiments on the artificial propagation of oysters may be mentioned. Professor Brooks, Lieutenant Winslow, Professor H. L. Osborn have all pointed out what an abundant "set" of spat may be had, and how rapidly the spat grows. An extensive survey of the oyster grounds of North Carolina was carried out some years ago, under the direction of Lieutenant Winslow;[1] and the U. S. Fish Commission, conjointly with the director of the Geological and Natural History Survey of North Carolina, Professor J. A. Holmes, has had in progress since last September a reëxamination of a part of the ground, with especial reference to the present condition of planted beds. As an outcome of this work we may expect to have, in the near neighborhood of Beaufort, a carefully planned and conducted experimental oyster farm, on which a continuous series of observations may be carried out for some years, with the sure expectation that improvements in oyster culture will result.

[1] Winslow, Lieutenant Francis. Report on the Waters of North Carolina, with reference to their possibilities for oyster culture, *State Printer*. Raleigh, 1886; Report on the Sounds and Estuaries of North Carolina, with reference to oyster culture, *U. S. Coast and Geodetic Survey, Bulletin No. 10*, 1889.

A year ago the director of the Geological Natural History Survey of North Carolina represented to the U. S. Commissioner of Fish and Fisheries, Hon. George M. Bowers, how desirable it was for the material development of the marine fisheries that some step be taken toward providing a headquarters, where continuous observations might be made on the natural history of the fauna of the south Atlantic coast, and how suitable the town of Beaufort was for such a purpose. In May Dr. H. M. Smith, in charge of the Division of Scientific Inquiry, announced (*Science*, Vol. IX, No. 227) the decision of the Commission to maintain, during the summer, at Beaufort, a laboratory for the prosecution of researches in marine biology. A suitable building was rented, and a proper equipment, including small boats, steam launch, dredges, trawl, etc., was provided. The laboratory was occupied from June 1 to September 15. A dozen naturalists were there, representing the Johns Hopkins University, University of Alabama, Baldwin University, Trinity College (N. C.), Guilford College, University of North Carolina. Mention has already been made of the fact that, in addition to the individual research work, considerable attention was paid to the accumulation of data on the local habitat, breeding times, etc., of the more abundant species of the region. The laboratory building is rented continuously, and the equipment and collections are stored there. The laboratory will reopen for work in June. As at Woods Holl, no charge is made to the occupants of tables.

While the temporary laboratory now organized at Beaufort answers many needs, it is greatly to be desired that a permanent Fish Commission station be established there. A bill providing the necessary appropriation for such a station is now before Congress. The policy of maintaining Fish Commission stations, at which ample opportunity is offered for scientific investigation, has been fully justified by the history of the station at Woods Holl. The results of the purely voluntary researches of the naturalists who have annually visited this station are of the highest value. In no way can the Fish Commission accumulate useful information concerning the animal and plant life of a region, so rapidly and at so little

expense, as by maintaining a well-equipped laboratory, open to all who come to study the natural history of that region. Professor Alexander Agassiz, in his report on the Museum of Comparative Zoölogy for the year 1894–95, points out the mutual advantages that result from coöperation between the Fish Commission and those engaged in research work in biology. Mr. Agassiz has especially in mind the Woods Holl station, but his remarks have a wider applicability. Mr. Agassiz remarks that "no university laboratory can hope to obtain the facilities accruing from the maintenance of the fleet of small boats and steamers, and of the personnel which forms a necessary part of the equipment of the Fish Commission Station"; and farther on: "The mere collecting of material for ordinary investigation, at a marine station, is not expensive, but it is expensive to carry on the continuous observations of eminent specialists, and subsequently to publish their investigations. *Such observations could well be carried on in connection with the work of a Government Fish Commission, and are not only germane to its investigations, but all important to their success.*"[1]

The bill providing for a marine station at Beaufort has the earnest support of many naturalists and college presidents in the North, West, and South. It is widely recognized how advisable, both from the scientific and economic standpoint, it is to have several stations along our coast at which observations may be carried on year after year. The wisdom of such a course becomes manifest when we consider the length of the coast, the difference in the character of its fauna at widely separated places, and the migratory habits of many animals (food fishes, etc.). It may safely be said that many of the most interesting economic problems, such, for instance, as the effect of the feeding ground on edible animals, and the possibility of altering such grounds, can only be solved after a comparison of results, obtained at various points on the coast, has been made, and the same is true for the broader study of variation in its strictly scientific aspect.

UNIVERSITY OF NORTH CAROLINA.

[1] Italics are mine.

THE FRUITING OF THE BLUE FLAG (IRIS VERSICOLOR L.).

JAMES G. NEEDHAM.

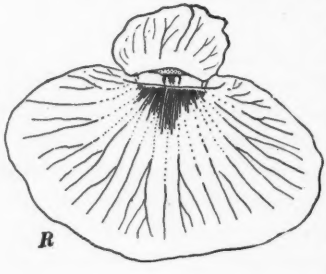
At the time of the adjournment of my college classes last June, I spent a few hours afield, watching the blue flags and their insect visitors, at first solely for the pleasant recreation that such study affords. But I soon made a few enticing little discoveries which set me to work in earnest. I began by locating all the clumps that were easy of access from my home in Lake Forest, and then I studied them daily during the flowering season, and almost daily thereafter throughout the summer.

The facts that first caught my attention were: (1) that there are many visitors to these flowers that seem to have been unnoticed hitherto; (2) that most of these are illicit visitors; and (3) that the ill-adapted ones are habitually deceived by the flower itself as to its proper entrance. I propose to give in the following pages the more important results of the season's observations.

It seemed to me that any new study of this so familiar flower should be undertaken on somewhat broader lines than are usually followed. The reproductive phase of the plant is a unit, and the flower is but one of a series of devices for furthering the reproductive process. Bud and flower and capsule and seed are the successive centers of interdependent ecological phenomena, determining the start in life of the next generation. I have tried to study the effect of insects upon the outcome of the reproductive process as a whole, and I discuss, below the chief ecological relations under the following headings: Pollination; The Waste of the Nectar; The Destruction of the Flowers; Fertilization; The Destruction of the Seeds; Inflorescence, and Chances of Maturing Fruit; The Relation of Habitat to Fertility; Alteration of Environment.

I. POLLINATION.

The flowers of the Iris have long been known to be entirely dependent on insects for the transference of their pollen. The structure of the flower has so often been described, there is no need of describing it again; if the reader has forgotten, he may refresh his memory by reference to the accompanying figures. He will recall a flower divided into three parts, requiring three separate visits by the insect which would obtain its stores; in each part an extrorse anther placed with its back against an overarching branch of the extremely large, three-parted style (Fig. 1, *R*); below anther and style a passageway to the nectary, with the usual guide streaks at its entrance, is formed by the channeled sepal. The stigma is restricted to the upper surface of an inferior, transverse, flaplike appendage of the style branch, just beyond the apex of the anther (Fig. 2). This flap is very thin and remains appressed to the style, with its free border toward the entrance, the stigmatic surface covered. The pollen-laden back of an entering insect, rubbing against it, readily everts the flap and deposits pollen on the stigmatic surface. Released, it closes



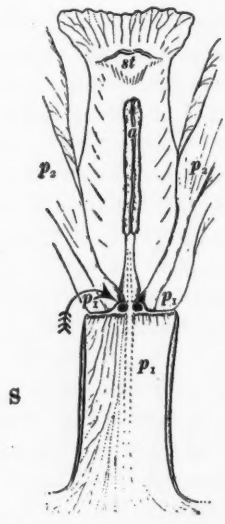


FIG. 1. — The entrance to the Iris flower, *R*, as seen from the front; parts undisturbed; *S*, as seen from the side with the sepal pulled directly downward; p_1, sepals; p_2, petals; *a*., anther; *st*., stigma. The arrow indicates the position of the proboscis of a pamphila when stealing the nectar.

elastically, and the rubbing of an emerging insect only closes it the more tightly.

Although the flowers are slightly protandrous, ripe pollen and fresh stigmatic surface may be found in the same flower at some period of æstivation. In case insects fail there is no provision for self-pollination by withering, as is the case in some members of the Iris family; the stigma, lifted away from the anther before maturing, remains so permanently.

I shall now discuss briefly the insects which I have seen to enter these flowers, taking them up in the order of their importance as agents of pollen distribution. I therefore begin with two small bees of closely similar size and habits: *Clisodon terminalis* Cr., *Osmia distincta* Cr.

These bees exhibit such perfection of adaptation as was the delight of the naturalists of Sprengel's day, and as will ever be delightful to observe. They were seen only in warm sunshine, during the season of abundant flowers; late and straggling flowers seemed to be neglected by them altogether. They were not the most numerous nor the most conspicuous visitors; but they visited very many flowers in rapid succession, securing the transference of the pollen with superior precision.

Each bee alights squarely at the entrance and without the slightest pause speeds down the arched passageway, and does not stop until its head is wedged in the bottom, with the proboscis extended through one of the two holes (see Fig. 1, *S*) leading to the nectary. A step backward and another momentary thrust of the proboscis, and away to another flower. That it rubs the stigma on entering may be seen by the tilting of the style tip; this is readily seen at a distance of several meters. *Osmia distincta* was perhaps a little less swift in its passage than the other, and this species alone was seen occasionally stopping on the way out from the nectary to scrape up some of the pollen fallen beneath its feet.

Next in order should be mentioned a group of syrphus flies: *Helophilus lætus* Loew.; *Syrphus torvus* O. S.; *Eristalis dimidiatus* Wied. Of these the first-named was a very common visitor. Of the other two I saw but a single specimen of each on Iris flowers, although the last-named was abundant on flowers

of the spreading dogbane. These are a little larger than *H. lætus*, and probably found the entrance way to the flower too close quarters. *H. lætus* visits the flowers for pollen only. Its proboscis is too short to reach the nectar. It wanders in at the entrance, rubbing first the stigma and then the anther with its back, swinging its proboscis from side to side, the terminal flaps sweeping the fallen pollen from the floor of the passageway. The down of its back was generally found well dusted with Iris pollen, and as an agent in pollination it was certainly second only to the bees above mentioned.

In the method of their operations these bees and syrphus flies stand in striking contrast. The bees enter and leave the flowers on the run, visiting very many in a remarkably short time; the syrphids loiter about the entrance, turning this way and that and, although entering cautiously, remain inside some time; but between visits they spend much time disporting themselves with their fellows in the sunshine. While a syrphus fly is visiting one flower a bee will visit a score.

Bombus separatus Cr. — The Iris and the bumblebee were the subjects of one of Sprengel's early studies on the relation between flowers and insects. Sprengel thought the bumblebee the only insect concerned with the fertilization of the European species (*Iris germanica*) which he studied. Müller attributed rather more importance to a very long-tongued, nectar-eating syrphid, *Rhyngia rostrata*. American writers on *Iris versicolor* have treated the bumblebee as the visitor of first importance. My observations do not corroborate this opinion. I saw but three bumblebees on Iris flowers during the entire season, and each of these was seen but a few seconds, entering from one to three flowers at one side only, and then departing. The visits were not such as bumblebees make to flowers which they habitually seek. They showed evident dissatisfaction. Indeed, they seemed to me ill-adapted. They are too large; they enter with difficulty and some delay, and crowd the stigma too roughly in passing. In the single visit which I was able to observe in detail the stigmatic flap was torn from the style for half its width; the bumblebee descended the passage with its proboscis retracted, made no

attempt at sucking, but scraped the trough of the sepal with its legs, gathering pollen.

Halictus disparilis Cr. — This minute bee is a common, though not a conspicuous nor an important visitor. It enters the flower by crawling beneath the tip of the style back downward, traverses the stigma, and walks back and forth, the length of the anther clinging to its underside, dislodging with its claws large quantities of pollen (Fig. 2). A strikingly large load of pollen is thus collected upon the hairs of its ventral surface. So it spends a long time under a single anther and visits but few in gathering its load. While it is highly probable that the bee everts and pollinates the stigma on

FIG. 2. — A minute bee (*Halictus disparilis* Cr;) collecting pollen from the Iris anther; *a.*, anther. *f.*, filament; *st.*, style. The arrow indicates the course of an insect entering the flower.

entering, it is certainly very wasteful of pollen. A more equitable arrangement is seen in its relations with *Ludwigia polycarpa*, which it visits in pools near by, and whose small flowers will furnish a load of pollen only for the traversing of a multitude of stigmas.

Trichius piger Fabr. — This ubiquitous flower beetle, observed by Robertson at Carlinville in the flowers of *I. versicolor*, was rather common here. The channeled sepal seemed a favorite place for an afternoon nap. I found several there undoubtedly asleep — one so soundly that, after carrying it about in the flower in my hand for half an hour, I still had a chance to wake it. After repeatedly tickling two of its feet that were hanging over the edge of the sepal it at length stirred, then stretched itself like a lazy boy awaking; in a little while it was lively enough.

I saw one beetle in the passageway eating fallen pollen. The species is not ill-adapted by its size for visiting these flowers, and should it pass directly from flower to flower, it

might be an important agent in pollen distribution; but I have not seen one pass from flower to flower directly and am inclined to think it rarely does so. It is little disposed to flight and is much more at home clambering among the thyrsoid clusters of Rhus and Ceanothus. Furthermore, on reaching an Iris flower it is habitually deceived as to the point of entrance and tries for some time to get in at its center, between the branches of the cleft style. After clambering in and out of the central cleft repeatedly the proper entrance is at length stumbled upon. It cannot, of course, reach the nectar, and the supply of pollen on the floor of the passageway is very meager. If seeking pollen it might, if it had wit enough, get plenty of it by entering the other side up.

Mononychus vulpeculus Fabr. (*the Flag Weevil*). — This beetle is one of the most characteristic insects affecting the blue flag, and one of the commonest. It is often found in the passageway to the nectary, picking up stray pollen grains, other grains sticking to its rostrum and feet and to the scaly ventral surface of its body, but not to its smooth back. What has been said of the preceding species, as to its part in pollen transference, and as to its activities in and about the flower, will apply almost literally to this species.

Desiring to learn whether they would transfer pollen properly, and finding too few entering the flowers of their own accord, I picked up a number of them with forceps and placed them in various positions on the flowers. They all, wherever placed, ran rapidly into the central cleft of the style, seeking to enter there, climbed out, and returned to try it again repeatedly. A few then climbed out at the sides between two sepals and crawled through the space between sepal and style into the entrance way, without touching either stigma or anther. A far larger number came upon the proper entrance. Most of these latter climbed over the tip of the style and down its outer face, entering back downward, traversing both stigma and anther. A lesser number wandered out upon the tip of the sepal and returned to enter right side up; owing to the lack of pollen on their smooth backs, these would effect nothing, though they touched the stigma.

Single individuals taken from the flower again and again and replaced on top, though they sought to enter speedily, went about it in the same bungling way as before. They did not readily learn by experience.

Xylota fraudulosa Loew.; Sepsis violacea Meig; Chlorops proxima Say; C. assimilis Macq.; Chrysogaster nitida Wied. — These active little flies are minor pollen thieves, all small enough to run into the open passageway, gather a few pollen grains, and run out with them. The first is large enough to brush a low stigma in passing, and the second, a strutting, micro-hymenopter mimicker, might strike a stigma with its tilting wings; but all are very unimportant, both in pollination and in their petty thievery.

Lastly, I should not omit to mention thrips, a few of which are to be found in almost every flower, and, antithetically, a humming bird (*Trochilis colubris* Linn.) which I saw make several thrusts, in succession, with its beak into the proper entrance of these flowers.

II. The Waste of the Nectar.

Two important sources of waste of nectar were much in evidence throughout the season — lepidopters and weevils.

A. Lepidoptera. — These were, by day, skipper butterflies (Hesperidæ), and at dusk, two species of moths[1]:

Eudamus tityrus Fabr., seen at flowers several times.
Eudamus pylades Scudd., seen at flowers but once.
Pamphila hobomok Harr., seen at flowers continuously.
Pamphila peckius Kirb., seen at flowers continuously.
Pamphila cernes Bd.-Lec., seen at flowers continuously.
Pamphila mystic Scudd., seen at flowers not uncommonly.
Leucania pallens (?), seen at flowers several times.
Evergestis stramentalis, seen at flowers several times.

The pamphilas were the most conspicuous and persistent of all visitors. Throughout the season one could find at even the

[1] Another moth, *Crambus laqueatellus* Clem., was seen twice, vainly plying its proboscis at the proper entrance.

smallest clump of flowers one or more of these skippers sitting in the position shown in Pl. I, Fig. *b*, far from anther and stigma, stealing the nectar. They get it with some difficulty, to be sure, the holes opening into the nectary not being visible from the outside. They must stand outside and insert the proboscis obliquely between the sepal and the base of the style, plying and thrusting with it until a hole is found. Repeated trials occasion loss of time, and when the hole is found not all the nectar adjacent to it can be reached from one position. Nevertheless, one cannot witness the persistence of the skippers, and their abundance throughout the season, without being convinced that they get a large share of the nectar.

Very interesting as bearing on the validity of long-accepted theories of floral coloration (which some are nowadays saying were accepted without sufficient experimental proof) are the habits of the pamphilas in visiting the flowers. When the question is raised, Do the guide streaks really guide? the pamphilas on the blue flags will furnish affirmative evidence. Fig. 3 shows a flower as seen from above. The center of the flower is at the deepest point between the divisions of the style, and the lines of these divisions all point toward the center, analogously to the guide streaks on the corolla of Convolvulus. There are special guide streaks, to be sure, at the proper points of entrance; but these are in unusual places and are also arranged radiately about the center of the flower. Pamphilas visiting the flowers *habitually try to enter at the center.* One will roam over the summit of the flower, returning to try for entrance at the central cleft, again and again. When one has strayed to the end of the style branch and stumbled upon the right entrance, it will generally be seen to try for a moment to enter there. After several ineffectual attempts at the center, it will pass over the edge of the sepal and descend backward or sidewise to the position shown in the plate (Fig. *b*). That something similar was observed by Professor Charles Robertson is indicated by the two words which I have underscored in the following quotation: "Sometimes butterflies obtain nectar in an illegitimate way, by *backing down* to the base of the flower and inserting their proboscides between the bases of the

'falls' [sepals] and the style divisions."[1] He mentions *Chrysophanes thoe* Boisd. and Lec. and *Pamphila peckius* Kirb.

I have mentioned above that the flower beetle, *Trichius piger*, and the flag weevil, *Mononychus vulpeculus*, are deceived as to the proper entrance in a quite similar manner, with the difference that when these stumble upon the true entrance they can enter there. I have never seen any one of these ill-adapted visitors alight directly at the proper entrance; all fol-

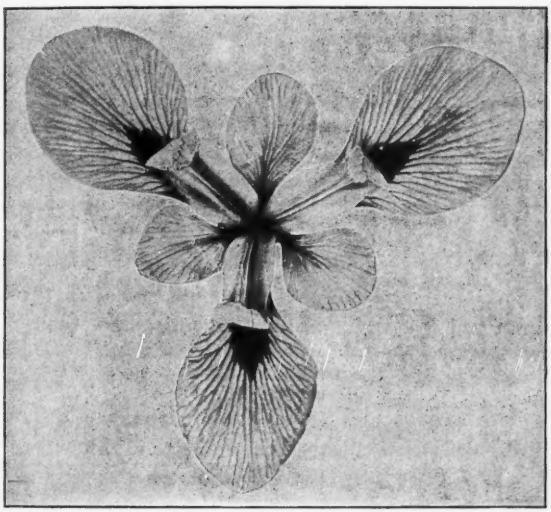


FIG. 3. — Top view of the flower; false guide streaks.

low to the center the lines simulating the guide streaks of an ordinary open flower. But the Iris flower was not evolved by these insects, nor with them. Proper visitors know where the entrance is and make no mistakes. And if the bees aforenamed pass from nectary to nectary with a speed that the eye can hardly follow, must we conclude that they are not guided by the coloration of the flowers? Must we say the striking lines of violet and yellow at the entrance aid them not, because they give no sign? I think not. I may enter a barber shop guided entirely by a striped pole and yet give no sign. I

[1] Robertson, Charles. *Botanical Gazette*, vol. xxi, p. 80, 1896.

believe it an analogy which does no violence to the truth if we compare a clump of the flowers to a business block in a city. Those whose business is there go about so automatically one might think they see nothing, while strangers have to stop and read the signs; and the rapidity with which the stranger will learn to feel at home will depend, not alone upon the persistency of his presence there, but also upon his mental adaptability to such knowledge.

B. MONONYCHUS (*the Flag Weevil and its Train*). — This weevil wastes the nectar inordinately. It stands on the outside of the nectary and, with its beak, sinks a shaft into the nectariferous tissue, nibbles a little, makes another hole, and another and another, until the nectar is left flowing from many punctures, attracting swarms of insects of all sorts. One is shown in Fig. *A* of the plate, together with a number of its attendants. It is no uncommon thing to find the ovary almost covered with insects following in the wake of the weevil, collecting the sap it has set flowing. The muscids are most numerous; I have seen a weevil making a puncture with three flies facing him and one on his back, all trying to get their proboscides to the puncture, crowding one another like pigs around a trough. During hours of sunshine, competition is so keen that insects with proboscides to insert into the beetle punctures (Muscidæ, Capsidæ, Pentatomidæ, etc.) seem to have a decided advantage. I have seen the following feeding at the weevil punctures:

Muscidæ, abundant, of a number of common species.
Capsidæ, abundant, especially the first named:
Pœcilocapsus goniophorus Say, in four varieties.
Pœcilocapsus affinis Reut.
Calcoris rapidus Say.
Lygus pratensis Linn.
Pentatomidæ, very common.
Euchistus ictericus Linn.
Euchistus tristigmus Say.
Podisus spinosus Dall.
Coccinellidæ, common.
Megilla maculata DeG.
Hippodamia 13-punctata Linn.

Lampyridæ, common at dusk and on dark days, especially the first-named:

Telephorus carolinus Fabr.
Podabrus basilaris Say.
Podabrus rugulosus Lec.
Lucidota atra Fabr.

The following insects, seen more rarely :

Mordella marginata Melsh.
Prosopis affinis Smith.
Prosopis nelumbonis Robt.
Worker ant (undetermined).
Male mosquito (undetermined).

III. The Destruction of the Flowers.

The flowers of the blue flag when bitten have a sweetish taste, which seems to invite their destruction at the jaws of a number of insects that are ever near at hand. I observed adult flag weevils, noctuid moth larvæ, and grasshoppers to be especially destructive while the flowers were in full bloom.[1] Any service the weevils may render as pollinators is greatly overbalanced by the destructiveness of their feeding habits. Not content with puncturing the walls of the nectary, they sometimes riddle the perianth leaves and the style divisions, destroying or (what is equally fatal) displacing the parts concerned in fertilization.[2]

All the grasshoppers (Acrididæ and Locustidæ) about the flag beds and in the neighboring sedges eat the freshly opened flowers, mainly nibbling a little at the margins of the petals or sepals and doing little real harm, but sometimes destroying the flowers completely.

The destructive moth larvæ were of three species: *Arsilonche albovenosa* Goeze, Mamestra *sp.?*[3] and *Spilosoma con-*

[1] Feeding upon the wilted flowers a day after they had closed and when their sap was souring were frequently observed the three following beetles: *Trichodes nuttalli* Kirb.; *Megilla maculata* DeG.; and *Telephorus carolinus* Fabr.

[2] This weevil has been reported by Mr. G. C. Davis as very destructive to imported garden Irides, at Flint, Mich. *Insect Life*, vol. vii, p. 201, 1894.

[3] I did not rear this species; two of my larvæ taken for rearing were parasitized with a species of Apanteles; the remainder (as well as many in the field) died of some bacterial disease. *Arsilonche albovenosa* was abundantly parasitized with *Rhogas intermedius* Cr.

grua Walk. At the time the Iris flowers opened, these larvæ were well grown. They then forsook the leaves, on which they had been feeding hitherto, for the daintier floral diet.

Chætopsis ænea Wied. and its Train. — This little bud-destroying ortalid fly deserves special mention, because in certain situations it does more to prevent fruiting than all other insect enemies combined. Furthermore, its attack comes earliest; its larva enters the pedicel at the base of the flower bud and bores downward into the common flowering stem (peduncle), killing not one bud, but the cluster of two or three arising at that point. Thus the flowers are killed before they open and are left to decay.

Walking through a pasture near Lake Bluff, Ill., one day, I was led to examine some large clumps of flags by the very bad odor of their Chætopsis-killed flowers. In clumps of several hundred plants each, not a single flower had been permitted to open. Finding Chætopsis larvæ still present in some of the pedicels, I collected a hundred or more terminal branches of the flower clusters and placed them on end in a jar, with a little water, some gravel, earth, etc., in the bottom, covered the jar with fine netting, and set it aside to await developments.

My little jar yielded, not a single species, but a little community — a succession of interdependent forms, such as one often finds among insects with a brief life history, able to take advantage of a transient food supply. First there appeared a number of pomace flies (*Drosophila phalerata* Meig), which had probably been attracted to the buds by the souring of their saccharine juices. Next appeared the ortalids (*Chætopsis ænea* Wied.), the cause of all the trouble. These I found left the stems when full-grown larvæ and pupated on the wet soil in the bottom of the jar. By this time the rotting buds were teeming with oscinid larvæ and studded all over the outside with pupæ, from which soon issued swarms of the minute fly, *Oscinis soror* Macq. With these also appeared a small number of beetles (undetermined) and a few parasitic Hymenoptera (*Spalangia drosophilæ* Ashm. and Heptamerocera *sp.*?). Finally, after the decaying buds had been completely overrun with mycelial

threads of fungus, there appeared fungus gnats (*Scatopse pulicaria* Loew.) in great numbers. It is quite probable that the ortalids attacking the fresh buds, the pomace flies coming when the saccharine juices of the flower first begin to ferment, the other flies and beetles clearing up the rotting débris, with a few parasites to hold the commonest in check, form an entirely natural succession of forms belonging with such conditions.

IV. Fertilization.

Not wishing to leave actual fertilization out of account, I (1) pollinated by hand a large number of flowers and marked them for examination later, and (2) counted the fertile and abortive ovules in a large number of capsules developing from flowers fertilized by insects. In my hand-pollination experiment half the flowers were treated with their own pollen, half with pollen from other plants. Before the seeds had grown sufficiently to be distinguished with certainty from the abortive ovules, grasshoppers and Mamestra larvæ had eaten all but a few. Those that remained happened to be half self-pollinated, half cross-pollinated, and the result may be worth mentioning, even though they were but few. The average by capsules was as follows:

Cross-pollinated,	ovules,	79;	fertilized,	74,	unfertilized,	5 (for 2 capsules).
Self	"	" 82;	"	16,	"	66 (" 2 ").

These were small capsules, from flags growing among thick sedges.

In a flourishing flag clump growing in the edge of a woodland pool I selected thirty well-developed capsules from flowers fertilized by insects, for the following tabulation. The position of the several capsules in the cluster is indicated by the lettering in the first column, which is the same as that of Fig. 4.

TABLE I. — AVERAGES OF FERTILIZATION BY INSECTS FOR 30 CAPSULES.

CAPSULES.	AVERAGE NUMBER OF OVULES.	FERTILIZED.	UNFERTILIZED.	PER CENT FERTILIZED.	NUMBER OF CAPSULES COUNTED.
I *a*	126	74	52	58.73	10
I *b*	129	57	72	44.96	5
I *c*	114	32	82	28.07	5
II *a*	123	44	79	35.77	5
II *b*	113	40	73	35.39	5
Totals	122	43	68	43	30

V. THE DESTRUCTION OF THE SEEDS.

I observed two types of seed destroyers, ecologically speaking: (1) those which are locally destructive, and (2) those which are with the flag in all the situations in which it grows. The influence of situation will be discussed under a subsequent heading, but here may be mentioned the insects locally destructive to the developing seeds. These are grasshoppers, Mamestra larvæ, and ovipositing damsel flies of the genus Lestes.

The grasshoppers are very destructive in meadow clumps and in the drier, more grassy situations, sometimes eating all the capsules over considerable areas, while generally disdaining to eat the leaves at all.

Of the three moth larvæ already mentioned as feeding on the flowers, only Mamestra remains to attack the developing ovary; the others return to their aforetime diet of leaves. But Mamestra, having once bitten into a juicy capsule, will eat nothing else thereafter, so long as capsules are obtainable. In my rearing cages a single larva would eat out all the seeds from a well-grown capsule in two days. Mamestra hardly comes into competition with the grasshoppers, since it avoids the drier situations where these are numerous enough to be destructive.

The injury from Lestes was still more local and was of a sort apparently not hitherto recorded. It was confined to flags

growing in standing water. The sheltered pools in which the Iris thrives best are the special haunts of these insects. *Lestes uncata* Kirby and *L. unguiculata* Hag. were abundant, and the females of these species punctured the fruiting stems so thickly in ovipositing as to kill perhaps a fourth of them. These egg punctures sometimes completely encircled the stem, but were more often confined to the more exposed side, overhanging the water. I observed as many as 250 punctures to the inch in length of stem in several cases. All were above water, some extending nearly to the top of the stems.[1] Nearly every well-exposed stem was thus killed outright or so injured as to prevent the maturing of its seeds.

Many other Odonata are seen constantly about the flag clumps. Longfellow singled out a natural associate when he wrote of the Fleur-de-lis:

> The burnished dragonfly is thine attendant;

but the showier dragonflies which habitually poise on the summits of the sword-shaped leaves have no ecologic relation to the Iris, save indirectly through their relations with other insects.

Of ubiquitous flag-seed destroyers I have found but two; the larvæ of a very pretty little tortricid moth, *Penthina hebesana* Walk., and the larvæ of the flag weevil (*Mononychus vulpeculus* Fabr.). The moth larvæ were common, the weevil larvæ, abundant; both were often found attacking the same capsule.

The larva of Penthina bores a hole into the seed capsule at its base, generally under the protecting tip of a bract, and eats its way upward through the seeds, usually consuming in its lifetime about half the contents of a single cell. Then it undergoes its transformations under the bract, or withered perianth, or in its burrow.[2]

[1] Egg parasites of Odonata have not in this country been hitherto reported; I bred from these Lestes eggs in flag stems five species of egg parasites and one hyperparasite, all of which proved to be species new to science. These are now in Mr. Ashmead's hands for description. These species of Lestes oviposit even more abundantly in Spharganium leaves.

[2] With this species there was occasionally found another tortricid (*Cacœcia rosaceana* Harris) of almost identical habits.

The flag weevil (*Mononychus vulpeculus* Fabr.) has already been mentioned as a denizen and, to some extent, a destroyer of Iris flowers. The height of the season for the adult weevils is the blossoming time of the flowers. Even then they are not very active; I have found them flying freely from clump to clump only in the hot sunshine of early afternoon. They will dodge around the base of the flower like a squirrel around a branch when a hand approaches, but they will rarely fly; they will oftener fall to the earth or into the water. The females when ovipositing are still more shy and difficult to observe. I was able to see the details of the process of egg laying on only one day — a very windy day, when everything about the weevil was in motion, and my own movements were, therefore, less noticed. The mother beetle rapidly gnaws a little hole through the wall of the ovary and, taking a few steps forward, inserts an egg into it. She then walks a little way and repeats the process or gnaws aimless little pits over the surface of the ovary.[1] The wounds thus made are quickly stopped by the discharge from mucilage cells, which are abundant in the walls of the ovary. The egg is often inserted into the external face of an ovule.

When the egg hatches, the larva at once begins a shallow furrow across the outer ends of the developing seeds, traversing from two to ten of them. Thus it spends the larger part of its larval life, doing no damage whatever. In fact, during this stage it is in considerable danger of being eaten, along with the seeds, by grasshoppers or Mamestra larvæ. Entering upon its last larval stage, the larva burrows downward and begins feeding on the softer tissues of the center of the seeds. It eats voraciously and grows with marked rapidity. It burrows parallel with the axis of the capsule through the center of from three to five seeds, leaving of them only empty rings. Its growth is completed and all its damage is done during this stage, which lasts only about a week. Then it transforms

[1] Possibly these blind pits may serve for the confusion of the weevil's parasites. I found a little egg, presumably that of a parasite, just within the entrance to a hole, at the bottom of which a weevil egg was lying. Mr. J. Hamilton found the parasites (*Ent. News*, vol. v, pp. 287, 288, 1894).

within its burrow and remains there as an imago, until the bursting of the capsules in autumn causes the seeds and the weevils to be shed together.

To determine the extent of the damage done by the weevil to the flag seeds, I picked at random, in several situations, fifty well-developed capsules and counted the weevils in them. The result by capsules was as follows:

Number of larvæ per capsule,	0,	1,	2,	3,	4,	5,	6,	7,	8,	9,	10,	12,	15,	16.
Number of times occurring,	3,	2,	4,	8,	4,	11,	3,	6,	1,	1,	2,	1,	1,	1.

Thus, but three were found without larvæ in them; two contained such numbers (fifteen and sixteen, respectively) that there were hardly enough seeds to insure their development; the total number of larvæ was 269, the average number per capsule, five. Each larva destroys on an average about four seeds; a preceding table has shown that the average number of seeds developing per capsule (among thirty counted) was forty-three. So it appeared that the weevils destroyed nearly half the seeds in capsules which had escaped other destroyers, all of which had had their turn first.

While this weevil is the most constant enemy of the blue flag, it is at the same time the one best regulated. Unlike other enemies, it is present on or in the plant throughout the season, and, though occurring everywhere, it is never wholly destructive anywhere. Its own habits furnish checks to too great multiplication. This is but saying that the weevil represents a higher type of ecologic specialization. It has become adapted for living on the blue flag exclusively. Other enemies might totally devastate the flag clumps and, in the next generation, turn to some other food plant; but excessive injury by the weevil means future starvation for its kind. The grasshoppers, Mamestra and Chætopsis, work a havoc that strikingly suggests a disturbance of the balance of nature. But the weevil goes its accustomed way — the way into which it has been led by natural selection — and gets its living unobtrusively; and save for the rather rare damage to flowers, which may as often be done after fertilization as before, the flags show no visible sign of the burden which, under natural conditions, they are doubtless able to carry.

VI. INFLORESCENCE, AND CHANCES OF MATURING FRUIT.

The flowering stem of *I. versicolor* bears a terminal cluster of three flowers and generally one or more lateral clusters of two flowers[1] each, the latter springing from the axils of alternating bracts. Fig. 4 represents a stem which bore the typical complement of flowers. For convenience of reference I designate these clusters by the Roman numerals applied to them in the figure. Cluster *I* is developed in all (100 per cent); cluster *II*, in about 60 per cent of the stems; cluster *III*, in about 10 per cent of them; and cluster *IV* is rarely developed; I found it but once during the season.[2] The small letters indicate the several flowers in the clusters and also the order of their opening. The clusters are nearly isochronous, but there is some irregularity. Flower *I a* is generally the first to open. The few flowers which I marked for observation opened in the morning before nine o'clock, and closed by withering during the afternoon of the day following. Flowers *a*, *b*, and *c* follow each other in regular succession, each being

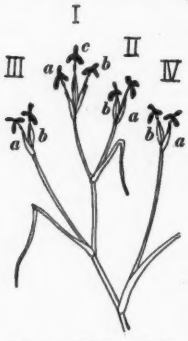


FIG. 4. — Diagram of the flower cluster.

[1] The statement of Goodale (*Wild Flowers of North America*, p. 32, 1882) that "the flowers may be single or in clusters of two, rarely more" is certainly not true for the vicinity of Lake Forest; I found but a single clump to which it would at all apply — a clump of much-dwarfed plants growing on a very dry hillock in a pasture near Fort Sheridan. This singular clump bore twenty flowering stems, of which five had cluster *I* only, with but two flowers (*a* and *b*) in that cluster; twelve had clusters *I* and *II* developed, with the second flower (*b*) developed in *II* but twice; and three with clusters *I*, *II*, and *III* developed, and only one flower (*a*) present in cluster *III*. Elsewhere I found three examples of cluster *I* in which a fourth flower (*d*) was developed, and two in which the third flower (*c*) was not developed. The usual four bracts were developed in all; but the terminal bract, usually sterile, was fertile in three, and the third bract, usually fertile, was sterile in the other two. I also found a single cluster *II* containing three flowers.

[2] These percentages were derived from a count of 214 stems — the same ones which were used in drawing up Table II. A subsequent count of 129 stems from other localities near Lake Forest yielded slightly different results, as follows: cluster *I* developed in all (100 per cent); cluster *II* developed in 87 (67.5 per cent); cluster *III* developed in 21 (16.3 per cent).

open for two days. Sometimes there is an interval of a day or two with no flower open. Some striking differences in time of flowering, due to situation, will be noticed under the next heading.

I collected 214 stems from five different localities and studied them to determine the proportionate fertility of the several capsules. Wholly infertile stems I disregarded altogether, and capsules developing any seed at all I counted fertile; Table II summarizes the results of the count. Disregarding localities for the present, the total percentages of fertility are as follows:

Flower	*I a*, 75 per cent;	*I b*, 63 per cent;	I *c*, 28 per cent.
"	*II a*, 66 per cent;	*II b*, 43 per cent.	
"	*III a*, 68 per cent;	*III b*, 54 per cent.[1]	

Clearly, the advantage is with the earlier flowers.

But is there not further significance in these facts? In connection with the occasional occurrence of an extra flower in clusters *I* and *II* they seem to me to suggest that the flower cluster is in process of reduction by elimination of the later flowers. The observations of one season will not determine such a matter. It is sufficient to record the conditions of the present, that the future student may have the criteria necessary for determining it.

VII. The Relation of Habitat to Fertility.

My observations were all made on the eastern slope of the narrow Lake Forest moraine, which forms a part of the west shore of Lake Michigan, its wave-worn eastern edge rising abruptly some seventy feet from the water. Numerous sharp, post-glacial ravines, whose puny streams take their origin among the pools, marshes, and "potholes" of the crest of the moraine and reach the lake level only at their mouths, give considerable variety to the otherwise uniform and scarcely perceptible eastward slope. I found and studied the blue flag growing in eight different sorts of situations. These will be referred to by numbers in the succeeding tables, as follows:

[1] The higher percentages for cluster *III* are somewhat misleading, because this cluster is developed only under the most favorable conditions.

Locality 1. — A small clump of perhaps fifteen plants, growing in the edge of a little creek that was formed by the confluence of a number of ravines, near the lake and almost at the lake level. But one clump was found in this situation, and it bore but fourteen flowering stems; but, because of its striking vigor, fertility, and comparative exemption from insect enemies, it is included in the table.

Locality 2. — A large area of flags, growing in an upland meadow pool that was the head water of one branch of the forementioned creek. This was the most extensive and the most typical of the clumps studied.

Locality 3. — A large and compact clump, growing in the edge of a woodland pool.

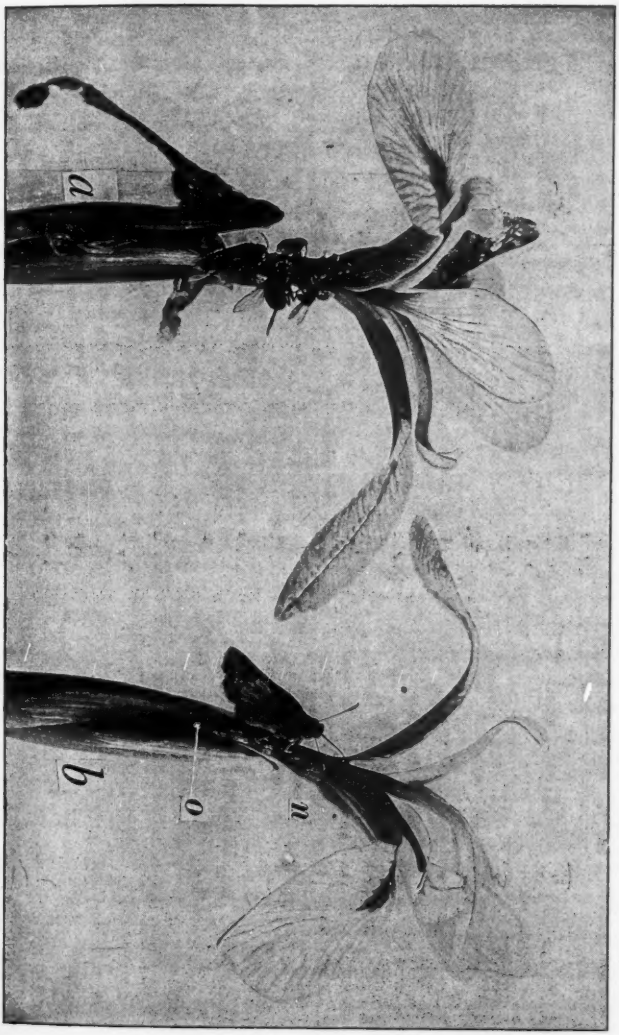
Locality 4. — Isolated single plants, growing between the sedges and the open water in a woodland pool.

Locality 5. — A large number of scattered plants, growing among the sedges of a "filled-in" pool.

Locality 6. — A typical glacial "pothole" in deep woods on the summit of the moraine, with abrupt banks, some depth of water in the middle, closely bordered with great oaks, and almost filled with a dense growth of buttonbush (Cephalanthus). The flags grew between the buttonbush hummocks and the shore, tall and spindling, with remarkably pale flowers. They bloomed late, the water of the pothole being rather cold, and, with the exception of two flowering stems which grew upon an unoccupied hummock, set no seed at all; hence this locality is omitted from Table II.

Locality 7. — At the foot of a hill bordering the creek mentioned above (locality 1), in a pool of cold water, the outflow from a spring, grew perhaps fifty plants, intermixed with cattails and sedges. These made a very promising appearance, but they bloomed late; the flowers were considerably damaged by weevils and set little seed, and that little was early destroyed and none left for tabulation.

Locality 8. — In a bottom-land pasture bordering the creek numerous large, apparently healthy, clumps on dry ground. This ground had once been marshy bottom land; but as a result of pasturage, tillage, and deforestation of the hills above floods



Pl. I. — Two Iris flowers, with some illicit visitors. Entering the cleft in the style of flower *a*, *Pamphila pecktius* Kirb.; on the left side of the nectary, a flag weevil (*Monoychus vulpeculus* Fabr.) surrounded by a group of Muscidæ; below, a lampyrid (*Telephorus carolinus* Fabr.), also seeking nectar. On flower *b*, *Pamphila cernes* Bd.-Lec. stealing the nectar; *n*., nectary; *o*., ovary. This, and Fig. 3, photographed from life by the author.

had increased, and the creek had deepened its channel, leaving the flag clumps high and dry. The flowers were destroyed by Chætopsis, setting no seed at all.

Thus, only the five first-named localities were available for the following tabulation.

TABLE II. — COMPILATION OF DATA ON IRIS FRUITING.

CLUSTERS.	FROM	NO.	CAPSULES FERTILE.								BY CLUSTERS.				
			a.	*Percentage.*	*b.*	*Percentage.*	*c.*	*Percentage.*	*Total.*	*Percentage.*	*All Abortive.*	*Both a and b Fertile.*	*Percentage.*	*a, b, and c Fertile.*	*Percentage.*
I	loc. 1	14	10		9		9		28	66%	0	8	57%	7	50%
	" 2	125	95		81		36		212	57%	0	74	59%	34	27%
	" 3	25	18		20		8		46	63%	0	13	52%	3	16%
	" 4	25	21		18		6		45	63%	1	16	64%	6	25%
	" 5	25	17		7		2		26	35%	0	7	28%	1	4%
	Total	214	161	75%	135	63%	61	28%	357	56%	1	118	55%	51	24%
II	loc. 1	10	7		4				11	55%	0	4	40%		
	" 2	75	56		39				95	63%	2	38	50%		
	" 3	15	10		7				17	57%	4	6	40%		
	" 4	13	8		5				13	50%	3	4	34%		
	" 5	15	3		0				3	10%	12	0			
	Total	128	84	66%	55	43%			139	54%	21	52	41%		
III	loc. 1	7	5		6				11	79%	0	5	71%		
	" 2	12	8		4				12	50%	0	3	25%		
	" 3	1	1		1				2	100%	0	1	100%		
	" 4	1	1		1				2	100%	0	1	100%		
	" 5	1	0		0				0		1	0			
	Total	22	15	68%	12	54%			27	61%	1	10	45%		
IV	A single example from loc. 1, both capsules fertile.														

This study by localities shows that the flags which grow in shallow water with open exposure to the sun have the better of it. Doubtless this but indicates their natural habitat.

The inference previously drawn from this table, that the earlier flowers have the advantage, is strikingly corroborated

by the study of localities 6 and 7, in which cold water and consequent late flowering are accompanied by nearly total infertility. While various reasons might be assigned for this advantage, I am inclined to believe that the principal reason is the coincidence of the visits of the bees, pollen distributers *par excellence*, with the time of blossoming of the early flowers.

The following table expresses in general terms the relation which ravage by insect enemies was seen to bear to situation. The first three columns express broadly the more potent features of the several situations. In six columns are indicated, by abbreviations of their respective scientific names, the six chief insect enemies: Mononychus, Penthina, Mamestra, Arsilonche, Orthoptera (grasshoppers), and Chætopsis; the numbers in these columns merely indicate the relative destructiveness of the insects named for each locality. In the last column is given the percentage of injury done by the species that was most destructive in each locality.

TABLE III. — RELATION OF INSECT RAVAGE TO IRIS HABITAT.

Loc.	Exposure to Sun.	Water.		Insect Enemies.						Highest Percentage of Injury.
		Amount.	*Temperature.*	*Mon.*	*Pen.*	*Mam.*	*Ars.*	*Orth.*	*Cha.*	
1	Open	6 inches	Warm	3	4	1		2		10
2	"	1–6 "	"	2	3	1	5	4	6	30
3	"	4 "	"	3	4	1	6	2	5	40
4	"	6 "	"	3	4	1	2	5	6	60
5	Overtopping sedges	Wet soil		5	6	2	3	1	4	60
6	Deeply shaded	0–20 inches	Cold	1						45
7	Open	0–4 "	Cold (spring)	1	4	3		2	5	50
8	"	Moist soil							1	100

So the blue flag is growing in certain native habitats now, under altered conditions, apparently not normal to it, in which it meets with enemies against which it is not fitted to cope.

VIII. ALTERATION OF ENVIRONMENT.

The blue flag has been less disturbed by the progress of civilization than most native species. Wild trees and shrubs and flowers have been uprooted, and cereals and forage crops planted in their place, for the farmer coveted their fields. But the Iris grows in wet places, not at once available for tillage. Yet it has suffered, both directly and indirectly; directly, through artificial drainage, drying up its native shoals; indirectly, through the influence of the change upon insects affecting its life history. It would be worth much to know, for the sake of comparison, what its relations to insects were before the white man came. In the absence of such certain knowledge there are facts of ecological adaptation which may justify an opinion as to some results of the change. To "civilization" I am inclined to attribute the following phenomena:

1. *The Destructive Abundance of Chætopsis ænea Wied.* — This species is an habitual enemy of the coarser, succulent grasses and cereal grains,[1] boring in their stems. Successive broods could not be maintained on the Iris, but the cultivation of corn and oats affords it almost unlimited opportunities for multiplication. A neighboring cornfield of the preceding year may well have furnished the swarms that devastated the Iris in locality 8. The scattering growth of the native coarser grasses in this region would not be likely to yield such swarms any season.

2. *The Injury locally wrought by the Grasshoppers.* — These were all field and meadow loving species, such as have doubtless become much more numerous in this region since the cultivation of their food plants was begun. Partial drainage, bringing the forage grasses and the flag clumps into closer proximity, would encourage the attack.

3. *The Nectar-Stealing of the Pamphilas.* — The constant presence of large numbers of these butterflies, so well adapted for another type of flower, upon the Iris, which is so well adapted to another type of insect, furnishes an example of

[1] *Vide* Howard, L. O. An Ortalid Fly Injuring Growing Cereals, *Insect Life*, vol. vii, pp. 352–354 (Fig.), 1895.

marked unfitness where nature generally shows the finest adaptations. "Civilization" may well be held responsible for this. The larvæ of the pamphilas feed on grass, and meadows and pastures have greatly increased the amount of grass available for their food. The butterflies, on the contrary, feed only on the nectar of wild flowers; these have correspondingly diminished in number; and the supply of nectar available for so specialized an insect has become very scant. They visit the Iris, because "stern necessity compels." They are equally abundant about the flowers of *Geranium maculatum* Linn., which blooms at the same time, and about every other species from which they can get any nectar. Were enough nectar available in flowers adapted to them, I think it quite likely that they would leave the Iris flowers unmolested.

I could not satisfy myself as to whether the apparent scarcity of the finely adapted bees (the only insects for which the nectar of the blue flag is made entirely available) was due to the diminishing of the nectar stores by the pamphilas or to some more remote cause effecting a decimation in the actual number of bees. But they were few about the flowers at the most favorable times; and the foregoing tables have shown the ovules incompletely fertilized.

I trust I have shown in the foregoing pages that the flower should be studied as only one factor in the reproductive process, its pollination, one of the links in the chain of circumstances, binding together two generations. It should be studied (1) in relation to local fauna and flora, (2) in relation to latitude, season, and situation, and (3) in relation to changing conditions of environment. Past studies of flowers and insects, though very numerous, are only complete in having completely demonstrated the interdependence of these and in having shown the existence of numerous coadaptations between them. There are broader ecological adaptations yet to be worked out, which may explain the fitting of a species to its place in natural society, but which will certainly require the coöperation of students, in various places and for a long time, content to spend much labor in gathering and correlating ecological data.

NOTE. — For help generously given me in the determination of the names of the insects mentioned in the foregoing paper I am indebted to a number of gentlemen, as follows: Coleoptera, Mr. Samuel Henshaw; Microlepidoptera, Professor C. H. Fernald; other moths, Professor John B. Smith; Hesperidæ, Mr. John Healy; Apinæ, Professor Charles Robertson; and, through the kindness of Dr. L. O. Howard, the following from the division of entomology of the Department of Agriculture: Hymenoptera, Mr. W. H. Ashmead; Diptera, Mr. D. W. Coquillett; Hemiptera, Mr. O. Heidemann.

A CONTRIBUTION TO THE NATURAL HISTORY AND DEVELOPMENT OF PENNARIA TIARELLA McCr.

CHARLES W. HARGITT.

I. Introductory.

The observations of which the following paper is a summary have been carried on during three summers at the Marine Biological Laboratory, and in part at the laboratory of the United States Fish Commission, from the directors of which I am very glad to acknowledge many courtesies and facilities for prosecuting the work.

The circumstances attending the work have been so varied during the years of its continuance that it may be hoped most of the errors liable to hasty observation have been avoided, and to a considerable measure the error liable to the personal equation of prepossession, where time is not allowed for its elimination.

Pennaria tiarella McCr. was first described by Ayers ('52), under the name of *Globiceps tiarella*, who has summarized its generic characters in substance as follows: Polypodon rising from a creeping root, branched. Short stems from the branches, supporting each a single polyp. Polyps encircled by three rows of arms, basal, median and near summit; the arms of the upper rows ending in globular heads. Polyp not retractile in tube. The name of the genus, Globiceps, from the peculiar form of the arms. The specific name from the number of the rows of arms. He gives no account of its distribution, except to mention that it has been taken at Sag Harbor and in Boston Harbor. Of its habitat he merely mentions that it occurs on fucus or similar substratum.

It was later described by Leidy ('55), under the name of *Eucoryne elegans*. McCrady ('57) was the first to recognize its true affinities with the Pennaridæ and designated it by the

name under which it is now known. L. Agassiz early pointed out nomenclatural objections to the name Globiceps of Ayers, and Eucoryne of Leidy, and at the same time indicated certain differences between the diagnostic characters of this hydroid and those originally designated as distinctive of the genus by Cavolini and Goldfuss. A. Agassiz ('65) in the catalogue of the North American Acalephæ has, however, followed the designation of McCrady, and has in turn been followed by most American students of the Hydroidea.

Still later, however, Allman ('71) took up the suggestion of the elder Agassiz concerning the unavailability of the generic terms Globiceps and Eucoryne and, discrediting the contention of McCrady as to the identity of the form with that of Pennaria, proposed the new generic name Halocordyle. He bases his claim for such distinction wholly upon the apparent difference as to the arrangement of the arms, or tentacles, those of the hydroid under consideration being distributed in verticillate whorls about the hydranth, while those of *Pennaria gibbosa* have them somewhat promiscuously distributed over the body of the polyp.

It might be sufficient warrant for doubt as to Allman's contention that his diagnosis is based chiefly upon published figures of the hydroid, having in neither case had access to living specimens. And when added to this there is recognized the further fact that a careful study of several species from different regions, and from the same region, shows all degrees of intergradation in these respects, an unhesitating dissent from Allman's view will not be regarded as extravagant.

II. MATERIAL AND METHODS.

The material chiefly used was obtained at Woods Holl during the summers of 1897, 1898, and 1899, and in almost unlimited quantities. Material of P. Cavolini was secured and preserved by the writer from the Bay of Naples in 1894, and was used in many points of comparison, as will be indicated in appropriate phases of the paper. In general, collections were made at low tide and in the waters in and about the harbor,

from eelgrass, piles of the Fish Commission docks, and from fucus and rocks in the shallowed waters in and about the rocky outlet of the "hole." Material specially for the developmental work was usually collected, when convenient, during the later afternoon, so that no considerable time should elapse before the discharge of the eggs. When by reason of tides this was not practicable, collections were made at other hours, and the material placed in floats off the exposed sides of the docks, where conditions of water, temperature, etc., would be as nearly normal as possible. Experiments, however, showed that this precaution was not essential, no apparent differences being distinguishable between collections brought to the laboratory aquaria and those floated outside.

For killing and fixing, many methods were tried, but without that marked preferential distinction for one or a few which is often found for other material. Almost any of the standard fixing agents will give fairly good results. If any preference is assignable, I should give it to the stronger solutions of Kleinenberg's picro-sulphuric acid, or picro-acetic, in which the acetic acid was often used in a solution as strong as 10 per cent. The various corrosive solutions gave results of about equal value, and for carmine staining was specially good. Perenyi's fluid gave fairly good results, though less certain than the others. Flemming's fluid, while affording admirable fixation, rendered subsequent staining so difficult as to make its value secondary.

For surface study of the eggs, out of a very large number of experiments with numerous staining agents, only one gave results of sufficient value to be worth record, namely, Conklin's picro-sulphuric-hæmatoxylin, and this, when compared with results upon such eggs as those of Mollusca, was quite inferior, though enabling one to distinguish definitely considerable of the internal organization of the egg from surface views. In no other egg, save that of Eudendrium, have I found such difficult material from which to secure even approximately good differential staining reactions. Whether this is due to some physiological condition peculiar to these eggs, or to their peculiar opacity, I am unable to say.

III. NATURAL HISTORY.

Pennaria tiarella is one of the most abundant and beautiful hydroids to be found in the waters of the northeastern Atlantic coast, occurring abundantly in tide pools, upon piles of docks, fucus, etc. Its generic name indicates one of its most conspicuous features, namely, the feather-like form of the main stem and its branches, which spring laterally and alternately from either side. When growing in dense tufts or colonies this feature is often obscured in a measure or, in some cases, even lacking entirely. In size it varies greatly as found under varying conditions of environment. Under the best conditions it may have a height of six inches or even more, while under circumstances less favorable it may scarcely have a height of more than two inches.

In this connection may be noted a rather interesting and, so far as I know, an unrecorded peculiarity of habitat, namely, its occurrence during the summer under apparently two conditions, the one appearing considerably earlier and finding a habitat, as already indicated, upon rockweed, piles, etc., the other occurring later and in great abundance upon eelgrass. The latter form rarely attains the larger size given, but it matures with much greater rapidity and has apparently a much briefer period of activity, hardly covering more than about four or five weeks. It is further distinguished by a higher coloration of the colonies and the medusæ. Again, the medusæ free themselves with much greater frequency and ease, and swim much more actively. The ova of the two forms likewise show the same difference of coloration, those of the latter being a brighter orange and much more conspicuous, while those of the former are of a creamy white, with the slightest tint of dull pink.

Morphologically these forms exhibit no constantly distinctive differences. The first, from its habit in usually deeper water, and thus constantly submerged condition, does not exhibit that marked feather-like bilateralism common in the eelgrass form, which, from the fact that it often floats upon the surface and, at low tide, often lies quite exposed, would come naturally to assume the bilateral form. This fact may likewise account in

part for the higher coloration exhibited by the latter, and might naturally occasion the more rapid development of the colonies, as well as the greater activity of the medusæ, since their exposure at low tide and always near the surface would give them the advantage of the naturally higher temperature of the surface water. May it not be probable that this condition is an adaptive one for the more rapid multiplication of the sexual persons which, by their greater activity, secure a greater distribution? For it must be noted that the medusæ of the deep-water forms are much less active, in many cases never becoming free at all, and when becoming so rarely swimming actively. During one entire season I failed to detect this feature which I have since found to be a very common one. At one time I was inclined to suspect that, as McCrady had suggested ('57), the ova might have developed within the bell of the medusæ and emerged as planulæ, for, in more than one collection brought in during the early morning, numbers of planulæ were found among the fucus-bearing hydroids, and among the stems of the colonies themselves, while the yet living medusæ were found still attached to the hydranths. McCrady's observations may have been due in part to the fact that in many cases these deeper water medusæ do not seem to discharge the ova freely, and, since the free exposure of the ova within the bell of the medusa insures usually their fertilization, so, as a matter of course, the development follows without interruption. It is more probable, however, that his observations were due to a misinterpretation of the singular phenomena of segmentation, to be described later.

After the discharge of the ova the medusæ, when free, continue to swim about actively for a time, but soon begin to show signs of decline and rarely live beyond a few hours, sometimes twelve or even twenty-four, though A. Agassiz has recorded their living in confinement for several weeks. My own observations, however, show no confirmation of this. They rather confirm the observations of McCrady, who remarks upon the "apathetic condition of the medusa, following the expulsion of the planules."

In common with most hydroids Pennaria is distinctively a

summer organism, at least in its actively vegetative condition. I have not found records of its occurrence in flourishing condition later than November, and during several years of observation have not taken it in mature form earlier than June, though its seasonal variation may be considerable. After its more active period there is an evident decline in vigor, and later a degeneration of the polyps and hydrocaulus, and a recession of the cœnosarc within the stoloniferous hydrorhiza, followed by a period, more or less prolonged, of quiescence. This is chiefly a seasonal peculiarity, induced doubtless by coincident changes of temperature, food, etc. It may occasionally, however, be induced by conditions purely local and temporary. Colonies now and then show an evident decline for a period of varying extent and then may revive and regain their normal activity within a few weeks. In these cases no discernible cause is evident, and hence they have been designated as purely local and temporary.

Pennaria exhibits in a very marked way the phenomenon of "alternation of generations." The nonsexual, or vegetative, phase comprises the splendid hydroid features whose natural history has now been outlined. Its sexual, or medusa, phase presents an organism which Agassiz ('65) has characterized as "one of the most remarkable of our naked-eyed medusæ." In form it is elongate-oval, slightly smaller at the oral end. In Pl. I, Figs. 2 and 3, are shown adult medusæ with developing and mature eggs. Its size varies slightly, but averages about 1.5 mm. in length, and .8 mm. in short diameter.

In its natural history the medusa exhibits some very interesting features. Some of these have already been pointed out, such as the variation in coloration, activity, etc. Smallwood ('99) has observed in working out its development evidences of degenerative conditions which harmonize with some of the observations previously cited, and with similar conditions among not a few other of the Hydromedusæ, *e.g.*, Clava, Hydractinia, etc.

The medusæ mature with comparative rapidity and show a rather marked periodicity as to the time of liberation. And here again there is a rather sharp difference between the so-

called eelgrass forms and those of the deeper water habit. The former are liberated usually from about 7 to 8 P.M., followed almost immediately by the discharge of the sexual products. In the latter form the time of liberation varies from about 10 to 12 P.M. In each case the male medusæ are, as a rule, first set free, usually from a few minutes to half an hour. Fertilization of the eggs occurs at once upon their discharge.

In Pl. I, Fig. 2, is shown a mature medusa as it appears within a few hours of its liberation from the hydroid. At this time the nearly mature ova occupy almost the whole interior of the bell, often distorting in some measure its form. In no case, however, have I observed any such remarkable distortion at this stage as that described and figured by Agassiz ('65), and I am disposed to suspect that his specimen must have been a very unusual one, for certainly with ova surrounding the whole of the manubrium and compressing it greatly a one-sided distortion must be rather difficult to understand. As the ova grow about the manubrium they are flattened, disk-shaped bodies of an outer convex and an inner concave aspect. Approaching maturity they begin to assume a more or less spherical form, as indicated in the figure. Just prior to the release of the medusa, and perhaps induced in part by the rhythmic contractions by which this is effected, they assume a perfectly spherical form; the mesenterial membrane becomes more closely fitted to each individual egg, and at the moment of release the animal has the form exhibited by Pl. I, Fig. 3. Swimming rapidly about with the characteristic jerking movements common to these smaller medusæ, the ova are discharged one by one as the animal swims, and thus a considerable distribution is secured to the ova and the new colonies to arise from them. In the growth and maturity of the male medusa essentially the same phenomena are exhibited. The sperms closely pack the whole subumbrella cavity, but as the medusa is about to be liberated the mesentery seems to contract, and quickly following this, as release is effected, the membrane is ruptured and the sperms discharged in immense numbers.

IV. MATURATION AND FERTILIZATION.

Under these heads I shall give at this time only the merest synopsis of my observations, for there are many points yet to be worked out in detail, and to these I shall give special attention in a later paper, which is, however, well under way and may, I trust, appear within the near future.

As Smallwood has pointed out ('99), and as Doflein ('96) has also shown for Tubularia, and as I have found in Parypha, the ova grow within an ovarian mass of primitive ova by the consumption of their fellows, nuclei of which may be seen in all stages of degeneration, both about and within the growing eggs. In Parypha the most perfect illustrations of degenerative metamorphosis and amitotic division are shown, and in this form they are not wholly disintegrated during the process of segmentation of the egg, nor even till after at least the ectoderm of the larva is very clearly established.

As the egg grows the nucleus migrates toward the periphery, becomes very indefinite in form, and also seems quite indifferent to ordinary staining processes. In only a few cases have I found from surface preparations, and in observations upon the living egg, any clear examples of polar bodies. However, the fact that the ova are devoid of membrane and are peculiarly opaque would naturally obscure or render quite transient these bodies. The ova are of relatively large size, varying from .4 mm. to .5 mm. in diameter, and heavily yolk-laden, and, as already indicated, vary in color from a creamy white with faint trace of pinkish hue to a clearly orange color.

Fertilization occurs very soon after the ova are discharged from the medusa, and hence only external, unless, as indicated in another part of the paper, where, after the velum is ruptured as well as the mesentery suspending the egg, fertilization may readily take place within the bell cavity. A number of experiments and observations have demonstrated this quite conclusively. Artificial fertilization is quite easy and can be controlled at will. Very soon after extrusion of the egg, sperms may be seen surrounding it in great numbers, in some cases completely covering it and adhering for some time. The

entrance of the sperm produces a profound effect upon the egg, which up to that time has been quite passive. Examined under a low power the egg very soon after access of the sperm shows a sort of convulsive surface torsion, which after a few minutes quite disappears, and the egg again becomes quiescent. But within half an hour, often sooner, the phenomena of cleavage begin and usually go forward with comparative rapidity, the entire process, so far as surface features are concerned, becoming complete within a few hours, though varying greatly in different eggs and under slight differences of temperature.

V. Cleavage.

Of cleavage phenomena in Pennaria it is extremely difficult to formulate an account, and that for several reasons. A glance at the figures which present only some of the more striking aspects of the subject will afford one, and perhaps a sufficient, reason. Again, the unusual opacity of the eggs renders difficult, either in the living or preserved material, any critical insight into other than the surface phenomena. There seems to be no law or order attending the process. Every egg is a law unto itself and is absolutely indeterminate as to order or rate of development. Beyond the accounts of Wilson for Renilla ('84), and Metschnikoff for Ratkea and Oceania ('86), the literature at my command affords nothing comparable, and these are only remotely so. Andrews ('98) points out "Some Ectosarcal Phenomena in the Eggs of Hydra," which, while in some features they are similar to some aspects associated with these phenomena in Pennaria, seem yet to be of a decidedly different character. Similar ectosarcal features were more or less obvious in the eggs of Pennaria, bits of protoplasmic matter at times being extruded and even detached from the surface of the egg, including at times considerable portions. Again, the presence of more or less definite protoplasmic bands, or bridges, during the earlier phases of cleavage is a very conspicuous feature in Pennaria. That it may in some way be associated with fertilization, the entrance of several Spermatozoa, artificial conditions, or otherwise, would seem not improb-

able. The highest powers of the microscope revealed nothing which seemed quite comparable with the so-called spinning movements of protoplasm, to which Andrews has directed attention.

So anomalous are these phenomena that during the first several series of observations the conclusion was unavoidable that they were strangely abnormal or, perhaps, pathologic. Accordingly, the first series were wholly discarded, except a few specimens which had been isolated in watch glasses and set aside more out of curiosity than otherwise, and left overnight. An inspection the following morning revealed several apparently normal larvæ. The observations of the following night were to the same effect, though at this time a considerable series of all sorts were isolated with pains to eliminate possible error, and with results quite assuring, in that in a very large proportion of the cases perfect larvæ resulted and continued to develop. Following this, systematic collections were made and painstaking observations and records kept of every feature associated with development.

Occasionally an egg would segment with a fair degree of regularity into the two, four, and eight cell stage, as shown in Pl. II, Figs. 7, 8. But beyond this point it was difficult to follow any order in the cleavage, though it might continue with more than ordinary regularity as compared with the average of its fellows. It was utterly impossible to trace anything like a definite lineage of cells, notwithstanding repeated and careful attempts. By no means was it possible to predict the direction or course or rate of any division beyond the first or second phase of the cleavage, and even then only occasionally.

While Wilson ('84) has noted a considerable degree of individual variation in the cleavage of Renilla, he is still able to reduce it to some half dozen types. With Pennaria, however, while it is possible to recognize some few rather predominating types in the earliest cleavage, as, for example, a centripetal, a centrifugal, and a vertical, yet they are not of sufficiently pronounced character to constitute well-defined types which are distinguishable as such. In no case were there any clearly defined and symmetrical equatorial phases recognizable, though

occasionally incipient aspects of it were detected. This may be due in part to the membraneless condition of the eggs, but perhaps rather to their more or less evident amœboid condition, which asserted itself in the earlier phases. Again, the eggs early became somewhat flattened and disk-shaped, and only as the external phenomena of cleavage were completed did they resume an approximately spherical form. In Pl. II, Figs. 1–6, are shown a single series of cleavage phases noted at intervals of ten minutes or less. All were sketched from life by the aid of a camera, and, as will be noted also, there are presented only the *earlier* phenomena. As segmentation progressed its superficial aspects became less and less evident, owing to the opacity of the eggs, and only in a few cases were attempts definitely made to follow it to anything like completion. In these and other figures will readily be recognized the amœboid aspects referred to above.

Reference has been made incidentally to the variable rate of segmentation. This feature was quite as marked as were others, both as to individual eggs and blastomeres. In many cases a single blastomere would divide at a rate quite phenomenal, so that it was difficult to sketch adequately successive phases, while others might remain in a state of inaction for an indefinite period or even be engulfed bodily into the more rapidly segmenting portion. Then, also, in many cases cleavage seemed to begin in a somewhat discoidal fashion at a single pole and only gradually extend to other portions, as shown in Pl. IV, Fig. 1. This could hardly be due to any marked inequality in the distribution of the food yolk, for in this respect the eggs of Pennaria seem to be quite isotropous, and indeed there seems little if any definite polarity of any sort evident in these eggs. Occasionally, as shown in Pl. IV, Fig. 1, cleavage appeared to advance from a single area, but in the large proportion nothing of the sort was evident, and, as Conklin ('97) has shown in molluscan eggs, where the greatest variation in matter of yolk distribution is distinguishable, there is none the less a perfect symmetry of rate and character of cleavage. This would seem to be only another illustration of the inadequacy of any known law as an explanation of all cleavage phenomena.

That these are really cleavage, and not merely amœboid phenomena, can hardly be matter of serious doubt, even when considered from the more superficial phenomena already presented. If, however, other evidence were needed, it is available in the greatest profusion from sectional sources, portraying the internal structure and organization of the egg. In Pl. IV, Figs. 1–6, are shown camera sketches, of a few sections only, of eggs in different stages of segmentation. That they are clearly correlated in general features with the superficial features already noted there is no doubt whatsoever, though there may be many points of detail which need attention, but which can only be touched upon at this time. That Pl. IV, Fig. 2, is comparable with that of Pl. II, Fig. 7, as a two-cell stage must be obvious at a glance. There are, however, here some interesting facts to which a moment's consideration may be directed. It will be seen, for example, that there are present, in the section, portions of several nuclear figures, a somewhat unusual condition at this stage of development. However, here again there is something in common with what Wilson has recorded in certain cases in Renilla, namely, the internal nuclear division preceding that of the cytoplasm which followed, or lagged, as it were, finally dividing at once into an equal number of cells. It is, however, quite different in that in these the nuclear cleavage seems constantly to outrun that of the cytoplasm. It had occurred to me that possibly there might be here what has been noted by Loeb ('99), Norman ('96), and others, namely, a sort of artificially produced cleavage of the nucleus, induced by some chemical or pathological stimulus. The comparison of many sections, preserved under different conditions, and by different methods, however, leads me to conclude that it is a perfectly normal condition so far as these particular eggs are concerned. I have also observed the same thing in the eggs of other hydroids, and Hickson ('93) calls attention to a similar condition in the cleavage of Allopora. It would seem as if from some cause, not perhaps easily distinguishable, that all the phenomena of cleavage in some of these organisms have been greatly modified, that in some way the nucleus and cytoplasm have, as it were, been thrown out of concord, and their

rhythmic relations disturbed to such an extent that this very erratic and anomalous type of segmentation has resulted. May it not be within the line of possibilities that the peculiar methods and conditions of growth and maturation of these and some similar eggs have in some way been the occasion of the disturbance? While only a suggestion, yet it seems not without the range of possibilities.

In Pl. III, Figs. 1–7, are shown conditions not uncommonly met with, which are specially interesting in that from one such were derived spontaneously two perfect embryos, a fact, so far as I am aware, quite unusual, if not unique, though Metschnikoff ('86) cites a somewhat similar case in the development of *Oceania armata.* It does not seem clear, however, from his account whether the cases are quite similar, certainly not in the details of the cleavage. Following the first cleavage in these eggs, during which the blastomeres become widely separated, the two halves proceed to develop quite independent of each other and show no disposition to reunite until the cleavage is quite advanced, apparently to the point of completion or nearly so, when usually they gradually approximate and finally fuse into a typical morula and develop into a normal embryo. In at least one case a specimen which showed this aspect in a very marked degree at an early stage gave rise to two perfect larvæ, though of small size. The specimen was carefully isolated in a large watch glass and set aside as a test case, and the next morning the larvæ were found in perfect condition, as indicated. Several others of similar character were subsequently isolated in the same way, but in only the one case did this spontaneous division show itself conclusively. That such cases, though rare, are not strange among these organisms may be very well conceded, specially when the peculiar phenomena associated with the early development are familiar.

VI. Completion of Segmentation and Formation of the Planula.

Following the more conspicuous and anomalous aspects already considered, the egg gradually assumes a nearly spher-

ical form, hard to distinguish from the freshly discharged ovum, almost all surface aspects of cleavage having disappeared. In this form it remains apparently quiescent for some hours, during which time, however, internal cell division goes on quite actively, as sections clearly show. With completion of this internal cleavage the embryo becomes a solid morula, with only the faintest indications of any differentiation into an ectoderm (*cf.* Pl. IV, Fig. 6). Following this, however, the specialization of an ectoderm soon takes place, and the embryo begins to assume the characteristic pyriform, or oval, shape of hydroid planulæ. Within from twelve to twenty hours cilia make their appearance over the ectoderm, and the free life of the larva is assumed. Up to this time, however, and for some time after, no definite endoderm has been formed; the entire mass of internal cells seem scarcely distinguishable from each other, except that near the central portion the remains of yolk débris are more or less apparent. It is not till after some hours of larval life that an endoderm is gradually specialized from the internal cell mass and takes on an appearance quite similar to that of the forming ectoderm. After the establishment of the diploblastic condition there still remain a mass of undifferentiated cells, intermingled with yolk granules, which seem gradually to disintegrate and are consumed as food by the developing larva, which, up to the polyp stage, is wholly without mouth or other means of taking solid food, though in all probability absorption of water with soluble matter in small proportion takes place.

The larval history of Pennaria seems considerably longer than the corresponding period of many other hydroids. In several cases specially noted the planulæ did not settle for attachment and transformation till some five days following the beginning of development, and only at the end of seven days were tentacles well marked, as shown in Pl. III, Fig. 10. The tentacles originate by a process of budding, the lower, or filamentous, series appearing first, those of the other series following somewhat later.

Secretion of the perisarc begins almost at once after the attachment of the larva, preliminary to transformation. At

first it is an exceedingly delicate, almost indistinguishable, transparent film about the base of the polyp. This gradually thickens and soon hardens into a sheath about the growing polyp, covering at first the entire larva. Annulation of the perisarc seems to occur at no very definite time or place in its growth. In some cases it is apparent almost from the first. In others it only becomes apparent at a considerably later time, and nearer the hydranth than the base. As to the significance of the annulations, either in origin or function, nothing very definite can be said. That the perisarc itself is a protective adaptation seems almost beyond question; but whether the annulations characteristic of this and many other hydroids is an additional adaptation, rendering the stem flexible, etc., may be doubtful.

VII. Abnormalities.

The eccentric forms of cleavage already considered naturally raise the question as to probabilities of corresponding anomalies among the larvæ of these forms, and also of the resulting polyps; whether at any rate any variation appears from the normal type of embryo. The answer in part may be inferred from a glance at Pl. I, Figs. 4–6. These represent but three out of a considerable number of eccentric forms observed during the progress of the work. As will be seen, Fig. 4 represents what might be designated as a twin planula, having a rather broad and blunt anterior and a bifurcated posterior. In Fig. 5 is represented a second type, quite common, which differs from the former chiefly in the shape of the body of the embryo, which is somewhat spindle-shaped, and also in the slender and attenuated character of the posterior bifurcated portions. In Fig. 8 is shown a third type which is somewhat unusual. The body portion is decidedly eccentric in shape, with irregular tentaculate processes arising from it at various points and of various sizes and shapes.

Whether such anomalies occur to any extent under perfectly natural conditions, of course, cannot be said. But from their occurrence under the most favorable conditions in aquaria, and since, moreover, they seemed in no way to interfere with subse-

quent development, it may be inferred that their occurrence in a state of nature is not in the least improbable. Similar abnormalities have been reported among other genera of hydroids, *e.g.*, Bunting ('94) figures embryos of very similar character. Now whether all such anomalous planulæ develop into normal polyp may not be easily determined. That many should not is only what constantly happens with the most typical. That some of them develop there is not the slightest doubt. In Fig. 6 is shown a specimen which had become fixed in the ordinary way and had developed tentacles upon apparently two polyps heads. And in this connection it may be noted that in many cases these anomalous processes have been seen to be resorbed into the body of the larva as it approaches the period of transformation. This may suggest that they are perhaps only temporary processes which may serve some temporary function of doubtful significance. The larva shown in Fig. 4 might suggest that it had its origin as a twin from a single egg which had segmented somewhat as represented in Pl. III, Fig. 4, where development of the two halves of the ovum had gone on so apparently independently. But in no specific case, several of which had been isolated and watched with care, had any such form resulted. Nor, further, in specimens of similar larvæ carefully sectioned was there any special evidence of such an origin.

I am rather disposed to consider them as due in all cases to the intrinsic prepotency of hydroids to bud and branch; for, as I have repeatedly observed, and as Pl. I, Fig. 8, will show, the budding propensity asserts itself very early in the polyp life.

Concerning abnormalities among adult hydroids of this genus I have made no extended observations. Bunting ('94) refers to several cases among Hydractinia and Podocoryne. But in these the polymorphic conditions would, it seems to me, render them specially favorable subjects in which to expect such divergencies, while in Pennaria, at least, this element is lacking.

In Fig. 1 of the text is shown a somewhat unusual, though possibly not abnormal, young polyp. As will be noted, its unusual feature consists chiefly in the total annulation of the

stem, including the branch. This is in rather striking contrast with those figured in the plates and in the well-known annulations of the stems of the Pennaridæ. I was for a time constrained to wonder whether this might not have been a specimen of some other genus which had accidentally been brought in with the collections and had developed along with the Pennaria. Such a supposition is not impossible of course, yet the general aspects of the hydroid are so peculiarly pennarian, the annulations excepted, that I am rather constrained to regard it as simply a specimen which exhibits, in an unusual degree, a phenomenon which in itself is one of the most variable among hydroid characters, and that it shows how unreliable must be such a character for diagnostic purposes.

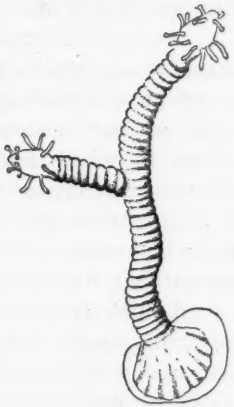


FIG. 1.

VIII. EXPERIMENTAL.

1. *Darkness.* — The liberation of the medusæ and the discharge of the sexual products upon the approach of darkness suggested this as a possible cause of the unusual activity at this time. Accordingly, several experiments were made to determine whether such were really the case. Colonies of both sexes were collected about 3 P.M. and were carefully excluded from light in suitable receptacles, but in no case could they be induced to discharge their products or become free at an earlier time, though that such conditions might have at some time in the life of the race been a factor in determining the periodicity of their maturity and release may not be improbable. But, as has already been pointed out, the fact that the deeper water forms do not become free or discharge the sexual products until toward midnight would certainly seem to suggest that darkness alone could not be the determining factor.

2. *Temperature.* — The observation that during specially warm weather larger numbers were liberated suggested the

possible influence of temperature upon the maturity of the medusæ, and suggested also additional experiments. Artificial change of temperature by means of heat or ice had a very noticeable effect, both upon the activity of the medusæ and the cleavage of the eggs, the reduction of temperature by a few degrees materially retarding the rate of cleavage, while raising it a corresponding amount proportionately accelerated these phenomena. This was likewise evident in the development and activity of the larvæ.

3. *Artificial Division of the Eggs.* — During the earlier phases of segmentation experiments were made to determine the effects of detaching small portions of the egg, in imitation of the observed spontaneous detachment of particles from the surface, to which reference has already been made. From repeated experiments it was conclusively shown that removal of small portions, and indeed of considerable portions, did not materially retard or modify the development of the eggs, or prevent their final development into perfect larvæ.

Again, the experiment of dividing eggs at the first cleavage, and at the second, and also of dividing them into several portions, was made in a considerable number of cases, with the results of obtaining from these fractions perfectly normal, though small, embryos, which continued to thrive and, finally, in the usual time transformed into perfectly normal polyps. Pl. III, Fig. 11, shows one of these half-egg polyps which was isolated and reared under conditions which leave no shadow of doubt as to the genuineness of the case. And this is only one of a considerable number, some from smaller portions, which were similarly secured. In Fig. 2 of text are shown a series of planulæ of normal and artificially produced specimens, in which the relative sizes are clearly exhibited.

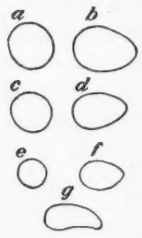


FIG. 2.

On a preceding page attention was directed to a rather remarkable feature, namely, the natural origin of two embryos from a single egg, by a spontaneous division at some point during the segmentation. These facts would seem to show conclusively that so far as the hydroids are concerned there is no such pre-

determined organization of the egg as that a given part must necessarily determine a given organ or part. For in the half or fourth embryos the number of tentacles arising in the polyp was of the same number and arrangement as in the normal one.

So, too, in the formation of perisarc, rate of growth, etc., there was nothing to indicate that the larva was other than a normal one in every respect, that of size alone excepted.

It may not be without the range of these facts to refer in passing to similar experimental work by Driesch, Wilson, Loeb, and others and to refer in particular to that which is in some respects rather unique. Concerning the capacity of portions of eggs regularly to develop into perfect embryos it is unnecessary to make special mention at this time. Loeb has shown ('93) that under the unusual stress of osmosis, induced by varying the density of the medium, double or multiple embryos of sea urchins might be produced almost at will. This has since been matter of common experiment. What seems to me of special note in connection with these experiments on Pennaria is that not only may such *experimental* results be obtained, but that similar results have been obtained in perfectly *normal* ways, that the entire phenomena of cleavage reproduce at some phase or other an almost identical counterpart of former experimentation along these lines. No one can follow the segmentation of the ova of Pennaria in its extremely variable and anomalous aspects without the conviction that there are here involved intrinsic forces, quite as pronounced as any which have been involved in the artificially operative chemical and physical agents to which reference has been made. That they may comprise much of chemistry and of physics is not questioned. But if so, they are intrinsic and integral.

SYRACUSE UNIVERSITY,
March 1, 1900.

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EXPLANATION OF PLATE I.

FIG. 1. Single colony of Pennaria, natural size, showing mode of typical branching, attachment to substratum, etc.

FIG. 2. Medusa about mature, showing form of ova at this stage, mode of attachment, etc.; *ov*, ova; *rc*, radial canals; *t*, tentacles.

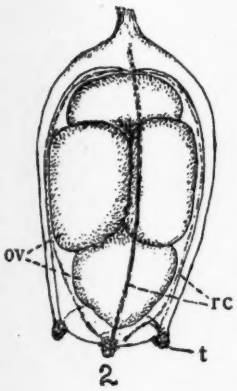
FIG. 3. Mature medusa, parts as in Fig. 2. Ova perfectly spherical, and clustered about the manubrium; *v*, velum.

FIGS. 4, 5. Abnormal larvæ, as found in several cases, showing the bifurcated condition.

FIG. 6. Rather unusual type of polyp, with small bud, *b*, on side of body, and with less than usual number of tentacles.

FIG. 7. Typical planula, about twenty-four hours after laying of the egg.

FIG. 8. An unusual larva, similar in some respects to that of polyp in Fig. 6, but with several bud-like developments, *b*, *b'*, *b''*.



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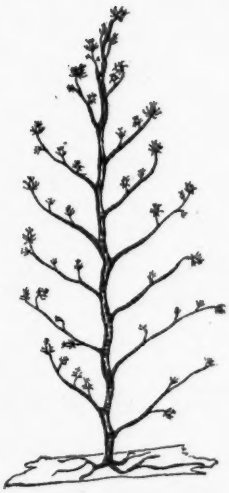

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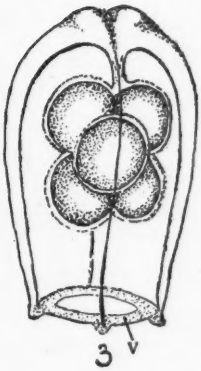

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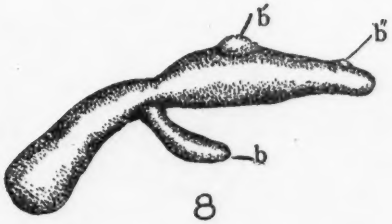

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EXPLANATION OF PLATE II.

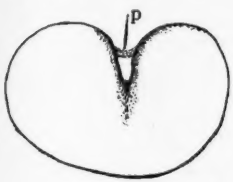
FIG. 1. Egg in first cleavage phase; *p*, a protoplasmic band connecting the blastomeres.

FIG. 2. A second phase of cleavage, indicated by furrow cutting off a small blastomere at *x*. Two protoplasmic strands are shown, one, *p*, the same as in Fig. 1.

FIG. 3. Next phase ten minutes later.

FIGS. 4–6. Show successive phases in progress of the development.

FIGS. 7–11. Show phases of cleavage in another egg, which differ in some respects from the former, yet resulting in practically same condition.



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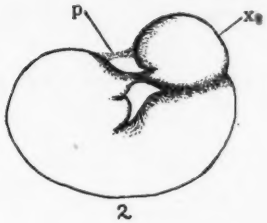

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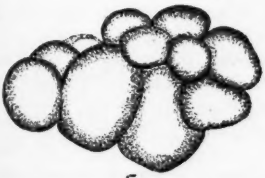

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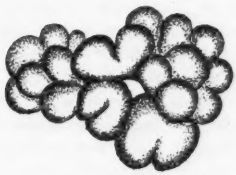

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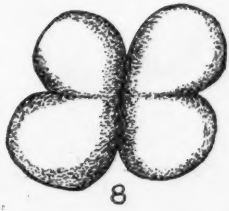

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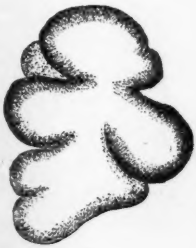

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EXPLANATION OF PLATE III.

FIGS. 1–5. Show a phase of cleavage not uncommon, in which, after the first division, the blastomeres segment in a perfectly independent way.

FIGS. 6, 7. Show the final coalescence of the two portions, and in Fig. 8, the resulting morula, which gradually assumes the planula form of Fig. 7 of Pl. I. The figures of this series are somewhat diagrammatic.

FIG. 9. Young polyp phase soon after attachment.

FIG. 10. Polyp with budding tentacles, *t*.

FIG. 11. Fully grown polyp, with full complement of tentacles, mouth, annulation of perisarc, etc. Sketched from life, with camera.

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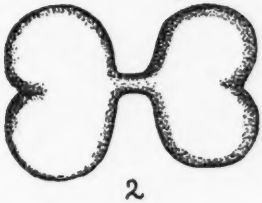

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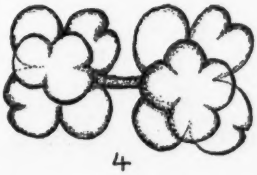

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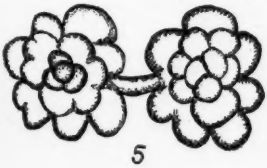

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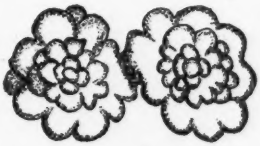

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EXPLANATION OF PLATE IV.

FIG. 1. Section of entire egg in early cleavage phase, showing more rapid rate at one pole, while the opposite shows a resting nucleus and no indications of segmentation. Camera sketch, × about 45.

FIG. 2. Two-cell stage. At the left is shown a perfect nuclear spindle, *sp*, and in the opposite blastomere several asters, which may indicate the nuclear divisions which have occurred, without involving the cytoplasm.

FIG. 3. Section of egg, × 135, showing various internal cleavage conditions, chiefly superficial; *n*, nuclei in resting condition.

FIG. 4. Portion of egg more highly magnified.

FIG. 5. Portion of another egg, showing essentially similar conditions.

FIG. 6. Section of egg at completion of segmentation, showing a mass of nuclei partially organized into a cellular ectoderm, *ec*.

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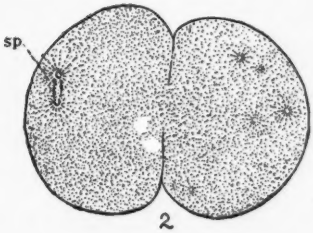

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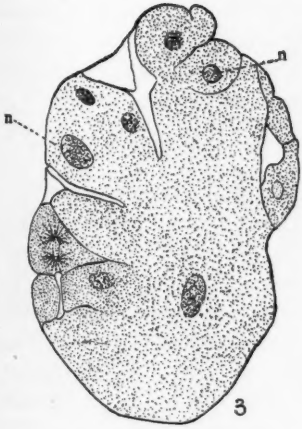

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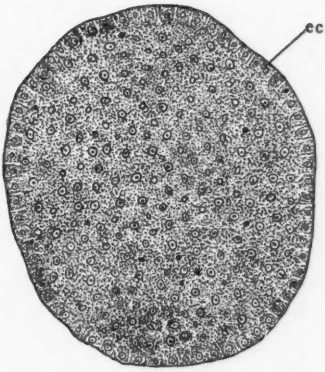

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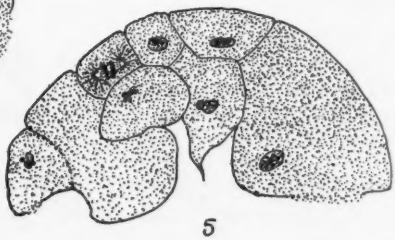

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THE ORNITHOLOGICAL RESULTS OF THE POLAR EXPEDITION UNDER DR. NANSEN.

(A REVIEW.)

R. W. SHUFELDT.

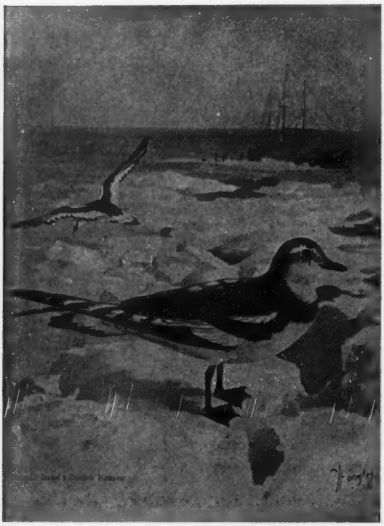
WHAT was accomplished for the science of ornithology during the journey of the *Fram* under Dr. Nansen and the intrepid explorers and naturalists who accompanied him in the North-European polar seas, during the years 1893–96, now appears in the form of a valuable quarto brochure, issued by its distinguished authors, to whom my thanks are due for a complimentary copy.[1]

This excellent work exhibits throughout great care in preparation, scientific accuracy, and a marked attention to details, descriptions and methods of presentation of the facts in the hands of its authors. It is handsomely printed and is illustrated by two plates devoted to Rosse's gull (*Rhodostethia rosea*). The first of these is an uncolored one, facing page 16, and represents two specimens of the bird, suspended by their legs in such a manner as to exhibit the pattern of the plumage upon their ventral and dorsal aspects. They were shot August 3, 1894. In the second plate, at the close of the work, we have a beautiful colored figure of this famous gull sitting on the ice, with another individual in flight in the background. In the distance we see the *Fram* firmly frozen in the ice pack, while far beyond the horizon the picture is completed by the cold red sky of those north polar seas. The birds in this plate are specimens of the young in first plumage.

By the aid of my camera I have copied this latter plate and offer it here as an illustration to the present review.

[1] *The Norwegian North Polar Expedition, 1893–96.* Scientific Results edited by Fridtjof Nansen. — IV. An Account of the Birds by Robert Collett and Fridtjof Nansen. Published by the Fridtjof Nansen Fund for the Advancement of Science. Christiania, Jacob Dybwad; London, New York, Bombay, Longmans, Green & Co.; Leipzig, F. A. Brockhaus, 1899. Cloth, pp. 1–54, 1 plate, 1 figure in text.

From the Introduction we ascertain that the work is divided into four (IV) sections. In the first three sections the observations recorded are extracted from Dr. Nansen's personal journals, and supplemented by his verbal comments and explanations during the preparation of the work. The first section (I) has to do with the journey along the north coast of Siberia, from Yugor Strait (July 29, 1893), until the closing-in of the ship to the northwest of the New Siberian Islands on Sept. 25, 1893 (78° 50′ N. Lat., 132° 20′ E. Long.).



Rosse's gull (*R. rosea*). Young in first plumage. From a photograph of original plate by the author.

"The birds observed during this time were principally on their way southwards. After the closing-in of the ship, no birds were seen until the following year."

The second section (II) gives the observations made at the time that the *Fram* was drifting with the ice towards the northwest, during the first summer, 1894, up to the time when Nansen and Johansen started on their sledge journey, March 14, 1895. This last point lies in about 84° N. Lat., 101° 55′ E. Long.

"The first bird seen in the spring of 1894 (a gull, probably *Pagophila eburnea*) appeared on May 13; birds were seen now and again until after the middle of August. After August 23, or the day when all the channels and lanes about the ship began to freeze up, no birds were seen."

Eight specimens of *R. rosea* were shot and preserved during this part of the journey. They were all young birds of the year.

The third section (III) gives the observations made during the aforesaid sledge journey, in the spring of 1895 to August 1896. During the journey in the Polar Sea, the first bird seen (a *Fulmarus glacialis*) was observed on May 29, when the travelers had begun to approach the north side of Franz Josef Land. That part of the journey in which the highest latitude, 86° 13.6′, was reached was undertaken so early in the year that "no birds were yet visible."

The fourth section (IV) gives the observations made on the *Fram* after Nansen and Johansen had left in March, 1895, until the return of the ship in August, 1896. Great importance attaches to the ornithological records made during this part of the exploration. In the first place, "birds were observed in the highest northerly latitudes, in which birds on the whole have been known to exist," and farthest north of all was found *F. glacialis*, of which a specimen was observed in 85° 5′ N. Lat.

During this part of the cruise, the *Fram* being confined to a comparatively limited area northeast of Franz Josef Land, the total number of species observed was ten (10), namely, *Plectrophenax nivalis*, *Sterna macrura*, *Pagophila eburnea*, *Rissa tridactyla*, *Rhodostethia rosea*, a specimen of a Larus, which is stated to have been black-backed, a Stercorarius (species undetermined), *Fulmarus glacialis*, *Cepphus mandti*, and *Alle alle*. "None of the species, however, seemed to occur in any great quantity."

"The last summer, 1896, when the *Fram* was north of Spitzbergen, the first bird (a snow bunting) was observed on April 25. It now appeared that for a distance of at least four hundred kilometers north of Spitzbergen, or between 81° and 83° N. Lat., the Arctic Ocean is inhabited by an abundant bird life, doubtless consisting principally of young, not yet mature birds, which spend the summer months here, in and near the open channels in the ice." "Among the specimens occurring here, sometimes in great numbers, may be named *Cepphus mandti*, *Alle alle*, and *Pagophila eburnea*. A few specimens of waders (*Ægialitis hiaticula* and *Crymophilus fulicarius*) were also found in these northern latitudes, and a specimen of *Xema sabini* was observed."

Under the names of the various birds observed in the body of this memoir are given full accounts of habits, localities, plumage descriptions, and matters of general interest to ornithologists everywhere. At the close of the work we find an index, which simply presents the scientific names of the thirty-three (33) species of birds observed during the entire journey. They are as follows: *Ægialitis hiaticula, Alle alle, Anser segetum, Archibuteo lagopus, Arquatella maritima, Branta bernicla, Cepphus mandti, Colymbus arcticus, Crymophilus fulicarius, Falco æsalon, Fratercula a. glacialis, Fulmaris glacialis, Harelda glacialis, Lagopus lagopus, Larus argentatus, L. fuscus, L. glaucus, L. marinus, Nyctea scandiaca, Pagophila eburnea, Phalaropus hyperboreus, Plectrophenax nivalis, Rhodostethia rosea, Rissa tridactyla, Somateria mollissima, Squatarola helvetica, Stercorarius crepidatus, S. longicaudus, S. pomatorhinus, Sterna macrura, Totanus nebularius, Uria lomvia,* and *Xema sabini.* In other words, it will be noted that there was but one passerine bird observed (the snowflake, *P. nivalis*); a ptarmigan, five waders, two hawks and an owl, two ducks and two species of geese; and the balance of the list, made up of gulls, terns, guillemots, auks, fulmars, jægers, and the dovekie, together with divers and puffins, represent strictly a circumpolar avifauna — few birds, and those essentially boreal forms. Taken as a whole, this is one of the most important contributions to the ornithology of high northern latitudes now extant, and it constitutes a very substantial addition to our knowledge of the habits, species and migrations, plumages and variations of the ornis of the Arctic Circle, and its distinguished authors are to be congratulated upon the completion of their worthy labors.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

IX. The Scorpions, Solpugids, and Pedipalpi.

NATHAN BANKS.

These three groups belong to that order of the Arachnida known as the Arthrogastra. It may be separated from the other arachnids of the United States, and practically of the whole world, in the following manner:

Abdomen plainly segmented, palpi of male not modified for a genital organ, rarely of small size, no jointed abdominal spinnerets *Arthrogastra*

Abdomen not plainly segmented, joined to the cephalothorax by a slender pedicel, palpi of male modified for a genital organ, at least one pair of jointed abdominal spinnerets . . . . . *Araneida*

Abdomen not plainly segmented, broadly united to cephalothorax, no jointed spinnerets, male palpi not modified, of small or even minute size *Acarina*

The three groups of the Arthrogastra treated in this paper are easily distinguished by the following characters:

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   Abdomen not ending in poison sting; no pectines, palpi not chelate at tips 2

2. Hind coxæ bearing a few *T*-shaped appendages, hind trochanters of two segments, no sternum, no patellæ in any legs . . . . *Solpugida*

   Hind coxæ without such appendages, hind trochanters not bisegmented, patellæ in at least some of the legs; sternum often present, body considerably constricted between cephalothorax and abdomen *Pedipalpi*

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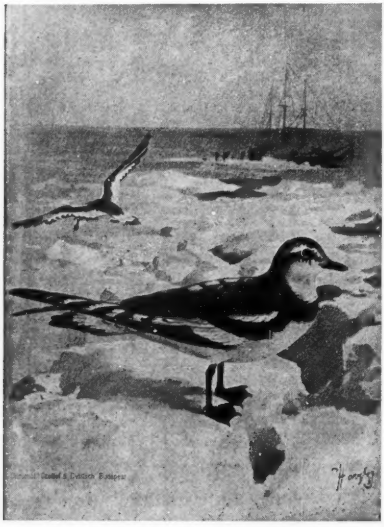
From the Introduction we ascertain that the work is divided into four (IV) sections. In the first three sections the observations recorded are extracted from Dr. Nansen's personal journals, and supplemented by his verbal comments and explanations during the preparation of the work. The first section (I) has to do with the journey along the north coast of Siberia, from Yugor Strait (July 29, 1893), until the closing-in of the ship to the northwest of the New Siberian Islands on Sept. 25, 1893 (78° 50′ N. Lat., 132° 20′ E. Long.).



Rosse's gull (*R. rosea*). Young in first plumage. From a photograph of original plate by the author.

"The birds observed during this time were principally on their way southwards. After the closing-in of the ship, no birds were seen until the following year."

The second section (II) gives the observations made at the time that the *Fram* was drifting with the ice towards the northwest, during the first summer, 1894, up to the time when Nansen and Johansen started on their sledge journey, March 14, 1895. This last point lies in about 84° N. Lat., 101° 55′ E. Long.

"The first bird seen in the spring of 1894 (a gull, probably *Pagophila eburnea*) appeared on May 13; birds were seen now and again until after the middle of August. After August 23, or the day when all the channels and lanes about the ship began to freeze up, no birds were seen."

Eight specimens of *R. rosea* were shot and preserved during this part of the journey. They were all young birds of the year.

The third section (III) gives the observations made during the aforesaid sledge journey, in the spring of 1895 to August 1896. During the journey in the Polar Sea, the first bird seen (a *Fulmarus glacialis*) was observed on May 29, when the travelers had begun to approach the north side of Franz Josef Land. That part of the journey in which the highest latitude, 86° 13.6′, was reached was undertaken so early in the year that "no birds were yet visible."

The fourth section (IV) gives the observations made on the *Fram* after Nansen and Johansen had left in March, 1895, until the return of the ship in August, 1896. Great importance attaches to the ornithological records made during this part of the exploration. In the first place, "birds were observed in the highest northerly latitudes, in which birds on the whole have been known to exist," and farthest north of all was found *F. glacialis*, of which a specimen was observed in 85° 5′ N. Lat.

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   Hind coxæ without such appendages, hind trochanters not bisegmented, patellæ in at least some of the legs; sternum often present, body considerably constricted between cephalothorax and abdomen *Pedipalpi*

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slender representation of them within our limits. These, however, belong to the three principal groups — Tartaridæ, Phrynidæ, and Thelyphonidæ. They are all of moderate to large size; there is a patella in at least some of the legs; there are no tactile organs on the hind coxæ; the mandibles are of moderate size; the body never ends in a sting; and the palpi are never chelate at the end; the abdomen is usually elongate, and when short it is not joined broadly to the cephalothorax, as in the Phalangida.

In the Tartaridæ the thoracic segments bearing the third and fourth pairs of legs are not united to the head, as in most arachnids, but free, and their scutæ showing as separate pieces on the dorsum. The abdomen is rather slender, tapering each way, and at tip is a long triangular telson. The palpi are short and terminate in a stout claw. The legs, except the first pair, are provided with a patella. The Thelyphonidæ are readily known by the presence of a long multiarticulate telson or tail; whence the popular name of "whip scorpions." The body is depressed and the abdomen joined broadly to the cephalothorax. Our single species, although greatly feared, is not poisonous.

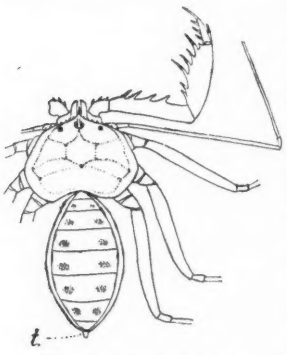

FIG. 1. — Admetus. *t*, telson.

The Phrynidæ are separable from the other Pedipalpi by the tenuity of the connection between the cephalothorax and abdomen. The body is broad and flat, without a tail. Of the three species recorded from our country, two are quite doubtful.

The Pedipalpi are tabulated as follows:

1. Cephalothorax transversely divided in posterior part, no eyes, telson short . . (fam. *Tartaridæ*) *Trithyreus pentapeltis* Cook (Cal.)
   Cephalothorax entire, eyes present 2
2. Abdomen with a long multiarticulate telson, abdomen quite broadly united to cephalothorax . . . . . (fam. *Thelyphonidæ*) *Mastigoproctus giganteus* Lucas (Tex., Fla., Ariz.)
   Abdomen lacking long telson, joined to cephalothorax by slender pedicel . . . . . (fam. *Phrynidæ*) 3

3. Frontal border of cephalothorax with long teeth, only two long spines on upper inner edge of tibia of palpus
Acanthophrynus coronatus Butl. (Cal.)
Frontal border of cephalothorax only denticulate, more than two long spines on upper inner edge of tibia of palpus, smaller species 4
4. Between the two longest spines of tibia of palpus there are two small spines . . . . . *Admetus fuscimanus* Koch (Fla.)
Between the two longest spines of tibia of palpus is only one short spine
Admetus whitei Gerv. (Tex.)

Scorpionida.

The scorpions are readily known from all other arachnids by the presence of two peculiar characters; the body terminates in a poison sting, and on the venter, near base of abdomen, is a pair of appendages, each bearing a number of lamellæ; these are the pectines, or combs. The palpi are enlarged at tip and chelate; the claw being of three parts, *viz.*, the hand, or basal portion, and two fingers, one movable, the other fixed. There are usually three groups of eyes. The last five segments of the body are much narrower than the others and form the cauda or tail. These segments bear ridges which are called "keels." The legs have no pa-

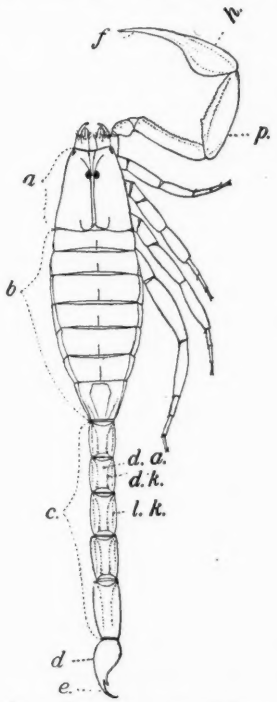

Fig 2. — Centrurus. *a*, cephalothorax; *b*, abdomen; *c*, cauda; *d*, telson; *e*, sting; *p*, palpus; *h*, hand; *f*, fingers; *d.a.*, dorsal area; *d.k.*, dorsal keel; *l.k.*, lateral keel.

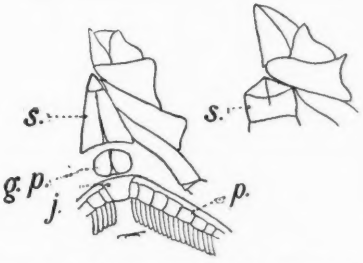

Fig. 3. — The two forms of sterna in scorpions. *s*, sternum; *g.p.*, genital plate; *j*, jugum.

tella. The exact number of species occurring in our country is uncertain, owing to the fact that several Mexican species may be found in southern Texas.

1. Only two lateral eyes; sternum broad, pentagonal; small short species (fam. *Chactidæ*) *Broteas alleni* Wood. (S. Cal.)
   Three to five lateral eyes 2
2. Sternum broad, pentagonal, usually no spine under the sting . . 3
   Sternum long, triangular, usually a spine under the sting . . . 14
3. At base of last tarsal joint at least one spur on inner and one on outer side; no spine under the sting . . . . (fam. *Vejoviidæ*) 6
   At base of last tarsal joint only one spur, which is on the outer side; sometimes a hump under the sting . . . (fam. *Scorpionidæ*) 4
4. A hump under the sting 5
   No hump under sting; cephalothorax deeply emarginate on anterior margin, cauda small, claws large, color dark
   Opisthacanthus elatus Gerv. (S. Fla.)
5. Comb with six to eight teeth . . *Diplocentrus lesueuri* Gerv. (Fla.)
   Comb with twelve to fifteen teeth
   Diplocentrus whitei Gerv. (Tex., Cal.)
6. Central area of each comb divided into at least eight small pieces 8
   Central area of each comb divided at most into six small pieces 7
7. Movable finger with at least five small teeth, sting of ♂ as usual
   Uroctonus mordax Th. (West Coast)
   Movable finger with at most three small teeth, sting of ♂ swollen at base . . . . . *Uroctonus phaiodactylus* Wood. (Cal., Utah)
8. Penultimate tarsal joint of three front legs with long hairs on back; a strong tooth near the under edge of the movable mandibular finger; very large and hairy
   Hadrurus hirsutus Wood. (Southwest)
   No hairs on back of these tarsal joints, no tooth near tip of under edge of movable mandibular finger, smaller species . . . (*Vejovis*) 9
9. Hand with distinct ridges or keels, more or less granulate . . 10
   Hand smaller, without keels, the corners rounded and smooth . 12
10. On the underside of the first caudal segment the median keels are distinct and sharp, although fine, the sting is very slender and long
    Vejovis punctipalpi Wood. (N. Mex., Nev.)
    On the underside of the first caudal segment there are no median keels or extremely indistinct, the sting of ordinary length 11
11. Hand strongly keeled, no keels on hind tibiæ, color yellowish or greenish . . . *Vejovis boreus* Gir. (Neb. to Idaho, Utah, and Nev.)
    Hand less sharply keeled, hind tibiæ with very plain keels, color uniform reddish-brown, legs paler . . *Vejovis mexicanus* Koch (Tex.)
12. On under side of first caudal segment the median keels are plain, but

not indicated by black lines, hand very slender, the fingers longer than in *Vejovis spinigerus*, color uniform yellowish
Vejovis flavus Bks. (N. Mex.)

On underside of first caudal segment no median keels, or at most only indicated by black lines 13

13. Underside of cauda not very dark, the keels all indicated by black lines, palpi usually yellowish
Vejovis spinigerus Wood. (Tex., Ariz., Cal.)

Underside of cauda, with the whole of dorsum and the palpi dark reddish-brown ; no black lines indicating the keels on cauda, smaller than the preceding . . . *Vejovis carolinus* Koch (S. C. to Tex.)

14. A tarsal spur at end of the first tarsal joints of legs 3 and 4 (fam. *Buthidæ*)

Pale ; no spine under sting, teeth on finger of palpus in many oblique rows, with stouter teeth at end of each and to one side ; thirty to thirty-five teeth in combs, under keels of last caudal segment very strongly toothed . . . *Uroplectes mexicanus* Bks. (Tex., Cal.)

No tarsal spur at apex of first tarsal joints, usually a spine under the sting . . . . . (fam. *Centruridæ*) 15

15. The oblique rows of teeth on the finger of palpus have on each side a parallel row of minute teeth . . . . . (*Centrurus*) 17

No parallel rows each side 16

16. The ends of the oblique rows of teeth overlapping, a distinct spine under sting, twenty to twenty-two teeth in comb, color dark red brown . . . . . *Tityus floridanus* Bks. (S. Fla.)

The ends of the rows not overlapping but often connected in one direct line, cauda and palpi very long and slender
Isometrus maculatus De Geer (S. Fla.)

17. No spine under the sting, cauda very long and slender
Centrurus exilicauda Wood. (Cal.)

At least a small spine or tubercle under the sting, cauda less slender 18

18. Body vittate with black and yellow 22

Body nearly uniform reddish-brown or blackish 19

19. Body a dark greenish-black, cephalothorax very rough, cauda strongly granulate . . . . . *Centrurus nigrescens* Pock (Tex.)

Body reddish or yellowish brown 20

20. Fingers paler than hand, yellowish, otherwise dark red brown, spine under sting often small and blunt *Centrurus margaritatus* Gerv. (Fla.)

Fingers usually darker than hand 21

21. Color yellowish-brown, combs with rarely more than twenty-four teeth, spine under sting not very prominent
Centrurus testaceus De Geer (S. Fla.)

Color reddish-brown, combs with usually more than twenty-five teeth, spine under sting well developed, usually much larger than the preceding . . . . . *Centrurus gracilis* Gerv. (Fla.)

22. A small pale median spot on the anterior border of the cephalothorax, legs pale yellow, cauda pale
Centrurus carolinianus Beauv. (S. States)
No such median spot on anterior margin of the cephalothorax, legs marmorate with brown, cauda brown, dark stripes on cephalothorax, broader than in preceding . . . *Centrurus hentzi* Bks. (Fla.)

SOLPUGIDA.

These curious arachnids are strongly separated from all other groups by various characters. There is a pair of thoracic stigmata; the cephalothorax is divided into three parts, the posterior two not covered with a chitinous shield; the mandibles

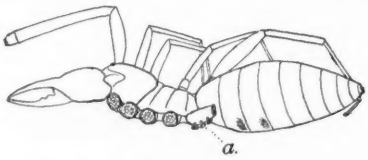

FIG. 4.— Eremobates. *a*, coxal appendages.

are very large and porrect; the hind coxæ bear several *T*-shaped appendages; the hind trochanters are bisegmented; the coxæ are approximate, so that there is no sternum. The body is not depressed in the slightest—a rare character in the other Arthrogastra (except Phalangida).

The species live in wild desert, often sandy, regions, and wander chiefly at night. Our genera and species may be tabulated as below.

1. Anterior margin of the cephalothorax rounded, sloping each side (*Ammotrecha*) 9 [1]
Anterior margin truncate . . . . . (*Eremobates*) 2 [2]
2. Movable finger of ♂ mandibles with two large subequal teeth with denticles between them 3
Movable finger with but one large tooth, others much smaller . 4
3. Some short conical spines under tibia of the palpus in both sexes
Eremobates sulphurea Sim. (Colo., N. Mex.)
No such spines under tibia in either sex
Eremobates formicaria Koch (N. Mex.)

[1] Ammotrecha, *n.n.* for Cleobis Simon (1879), not Dana (1847).
[2] Eremobates, *n.n.* for Datames Simon (1879), not Stal (1875).

4. Movable finger of ♂ mandibles constricted from below near apical third
Eremobates californica Sim (Ariz., Cal.)
Movable finger not constricted from below 5
5. The movable finger near apical fourth is suddenly narrowed from above, very large species . . . . . *Eremobates cinerea* Putn. (Ariz.)
The movable finger, if narrowed from above, it is much before the apical fourth 6
6. Only slender hairs on inner side of femur and tibia of ♂ palpus
Eremobates pallipes Say (Kan., Tex., Colo., Wy.)
Spine-like bristles on inner side of femur and tibia of ♂ palpus 7
7. Upper finger stouter than usual, narrowed near tip, a small tooth near middle of movable finger, tips of palpi black
Eremobates magna Hanc. (Tex., Ariz.)
Upper finger slender throughout, no tooth near middle of movable finger 8
8. Small conical spines on underside of tibia of ♂ palpus
Eremobates formidabilis Sim. (Cal., Ariz.)
No such spines on tibia of ♂ palpus
Eremobates putnami Bks. (Cal.)
9. Lower finger of mandibles finely, but distinctly, denticulate beyond large teeth ; a broad dark band on middle of metatarsus of palpus
Ammotrecha californica Bks. (Cal.)
Lower finger not denticulate 10
10. Upper finger with a very plain ridge above at base, below there are several small teeth followed by three large subequal teeth
Ammotrecha peninsulana Bks. (Ariz.)
Upper finger with less distinct ridge, below there are two large teeth, a small one, then a large one . . *Ammotrecha cubæ* Lucas (Fla.)

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

The Natural History of the Musical Bow. — Mr. Henry Balfour, the distinguished curator of the Pitt-Rivers Museum at Oxford, has recently published a monograph of eighty-seven pages, with many illustrations, upon the Musical Bow. The archer's bow is regarded as the prototype of a large series of stringed instruments of music. Though some writers consider the bow as the origin of all stringed instruments, Balfour believes that we must refer back to a plurality of ancestors for this class of instruments. Three stages are observable in the transition from the archer's bow, pure and simple, to the bow adapted specially for the production of musical sounds.

1. The archer's bow is temporarily converted into a musical instrument at the present day by the tribes of southwest Africa — the Damaras, Mandingos, Kaffirs, etc.

2. The second stage is represented by those monochord instruments that are practically bows and nothing more, but which are made for musical purposes alone. These are found in the Niger and Benue river regions, in the Kamerun, Lower Guinea, and Fernando Po countries.

3. The third stage is that in which a resonator is attached more or less permanently to the bow. To this class belong a large number of African instruments covering a wide area, chiefly south of the equator, and principally associated with people of the widespread Bantu stock.

Mr. Balfour is "convinced that nothing of the nature of a musical bow is represented" by the figure in the Mexican codex, which Mr. Saville identified as a musical instrument used by the ancient Mexicans. The author believes that the custom of using the musical bow in America was introduced from Africa. The accompanying map shows that the instrument is used in Patagonia, Bahia, Surinam, Central America, Mexico, and the West Indies in the New World. It is not found outside of India and Japan in Asia. In Europe the bow has been the legendary prototype of musical instruments in Greece and Rome. It is not found in Australia. F. R.

Report of the United States National Museum, 1897. — In a monograph of 282 pages Mr. Joseph D. McGuire describes "American aboriginal pipes and smoking customs." Two hundred and thirty-nine figures in the text and four plates illustrate the various types of pipes and their distribution over the American continent.

The custom of smoking prevailed in the New World for centuries before the arrival of the whites. The pipes used were of an endless variety of substances, shaped in as many forms as there were materials. The straight tube was the most primitive form and was the only one common to the whole continent. Mr. McGuire's conclusions are too extended for presentation in a brief review, yet it is worthy of note that he regards many types as modern — produced subsequent to the time of the discovery. For example, "The disk pipe, usually found in the states of Illinois, Missouri, and Kentucky, with specimens from Ontario, are of mound type, though their outline is so similar to the jew's-harp as to raise suspicion that such an instrument furnished the model for the pipe." "The Iroquoian pipes found along the river St. Lawrence and in the neighborhood of the Great Lakes may be said to vary one from the other more than pipes found in the eastern United States. . . . These pipes with but slight doubt show that their period is subsequent to the arrival of the French." "The form called the Delaware pipe appears to be of totemic character, is carved with considerable skill, and impresses one as being of recent origin, and made with modern metal tools." Even the skillfully shaped mound pipes are believed to have been made with metal tools obtained from the early French traders and voyageurs.

"Te Pito Te Henua, known as Rapa Nui: commonly called Easter Island, South Pacific Ocean," is the title of a belated article by Geo. H. Cooke, surgeon, U. S. N. The island lies 2.100 west of the South American coast and 1.100 east of Pitcairn Island, the nearest inhabited land. In 1886 the population had been reduced from several thousand to 155 natives. The mental and physical characters of the people are described, a vocabulary of three pages is furnished, and some account is given of their villages and habitations. The remarkable ruins of the island were reported upon by W. J. Thomson, U. S. N., in the *U. S. National Museum Report for 1889*. Dr. Cooke alludes to the belief among the present inhabitants that their own ancestors carved the megalithic monuments.

"The Man's Knife among the North American Indians — a study in the collections of the U. S. National Museum" — is a paper of eighteen pages by Professor O. T. Mason, and supplements that published in 1890 upon "The Ulu, or Woman's Knife." The knives used by the men of the American race may be classified in three groups: the curved knife, straight blade, and a metal blade performing the function of a burin. With the introduction of iron the arts of the peoples using the curved knife were greatly improved. This is especially noticeable in the Northwest, where the carving of the older period with beaver-tooth or shark-tooth knives was of an inferior kind.

"Arrow Points, Spearheads, and Knives of Prehistoric Times," a profusely illustrated paper of 188 pages, by Dr. Thomas Wilson, concludes the volume. After dealing with the spears and harpoons of the paleolithic period, the origin, invention, and evolution of the bow and arrow, and superstitions concerning arrow points and other prehistoric stones in the opening chapters, Dr. Wilson describes the flint mines and quarries in western Europe and in the United States. From the quarry at Spiennes, Belgium, flint implements have been distributed over southern Belgium and northeastern France. Fifteen neolithic stations, extending over forty-five communes, have been found, all in direct relation with Spiennes, creating a network of roads which have remained in use until modern times.

At Grand Pressigny the débris of the flint quarries still encumbers the ground for miles around. It is of a peculiar yellow or waxen color, and hence can be easily traced through northern, western, and central France, and even into some of the lake dwellings of Switzerland. At Mur-de-Barrez, France, shafts and galleries were dug in the search for the best flint. Perhaps the best known quarry is that at Brandon, England, which covers twenty acres and consists of shafts or pits partly filled, dispersed over the surface, sometimes so close together as to break into one another.

The best known flint quarry in the United States is at Flint Ridge, Licking County, Ohio. The ridge is about eight miles in length east and west, and two and one-half north and south. The flint is not in nodules, but in a continuous stratum from three or four to seven feet thick. The worked area is about two miles square and is covered with soil to a depth of four to ten feet.

The composition and structure of the materials employed in the manufacture of arrow points and spearheads are illustrated in repro-

ductions from microscopic sections. These weapons are then classified in several groups, according to their shape. Dr. Wilson believes many of the "humpbacks" were not rejects, as has been supposed, but that they were intentionally chipped into this form to be used as knives. Again, many of the implements having the form of arrow and spear points were intended to be used as knives.

F. R.

The Report of the Commissioner of Education for 1897–98 contains a vast amount of information relating to educational interests in America and in foreign countries. A chapter is devoted to education in Cuba, Porto Rico, and the Philippines. Besides the education of the older civilized countries, that of Australia, Tasmania, and New Zealand, of India and various South American republics, is considered. Of special interest to anthropologists is the chapter upon psycho-physical and anthropometrical instruments of precision in the laboratory of the Bureau of Education. Many of the ninety-two illustrations represent new pieces of apparatus. Dr. Arthur MacDonald contributes an exhaustive experimental study of Washington school children (pp. 989–1140). The investigation included a special study of 1.074 children and the anthropometrical measurement of 16.473 white and 5.457 colored children. His conclusions as to the children specially studied were :

1. "Dolichocephaly, or long-headedness, increases in children as ability decreases. A high percentage of dolichocephaly seems to be a concomitant of mental dullness.

2. Children are more sensitive to locality and heat on the skin before puberty than after.

3. Boys are less sensitive to locality and more sensitive to heat than girls.

4. Children of the non-laboring classes are more sensitive to locality and heat than children of the laboring classes.

5. Colored children are much more sensitive to heat than white children. This probably means that their power of discrimination is much better, and not that they suffer more from heat."

In Dr. MacDonald's conclusions from study of the larger series of children we find the surprising statement that "in colored children brightness increases with age — the reverse of what is true in white children."

An educational directory concludes Part I of Vol. I. F. R.

Notes. — The Smithsonian Institution has issued a reprint, in a single pamphlet, of two papers by Professor Otis T. Mason that were published in the *Smithsonian Reports* for 1876 and 1884: "The Latimer Collection of Antiquities from Porto Rico in the National Museum," and "The Guesde Collection of Antiquities in Point-à-Pitre, Guadeloupe, West Indies."

In his preface to the reprint Professor Mason states that considerable literature has accumulated relating to the Greater and Lesser Antilles since the first publication of the papers. The number of collars known now amounts to one hundred, the number of zemes has been also greatly increased. The Guesde collection is easily identified with the Carib work of the continent of South America. The preface concludes with a list of publications relating to West Indian antiquities which contains thirteen titles.

In the *Proceedings of the Linnæan Societies of New South Wales* Mr. R. Etheridge, curator of the Australian Museum, describes the spear becket of New Caledonia. The beckets in the Australian Museum are from six to thirteen inches long and are of plaited cord, with an "eye" at one end and an "overhand" knot, or a "grummet head," at the other. The cord is a square or flat sinnet made from tightly twisted rush or grass, or a less tightly twisted beaten-bark string. Labillardière is quoted as authority for the statement that the beckets of New Caledonians were of cocoanut fibre and fish skin at the beginning of this century. Twelve beckets are figured in the five accompanying plates.

Mr. Etheridge describes also the "widow's cap" worn during the period of mourning by Australian women. It is of gypsum plaster, two or three inches in thickness, and varying in weight from four to fourteen pounds.

Mr. W. R. Harper gives an account of the exploration of aboriginal rock shelters at Port Hacking, Australia. Human skeletons and objects made by man were found. Two of the three shelters mentioned contained impressions of hands in red and black pigment.

The *Annual Report* of the director of the Field Columbian Museum for 1898–99 contains a number of valuable plates, a half dozen of which are of anthropologic interest. The list of accessions to the department of anthropology includes several groups of figures illustrating aboriginal industries and customs.

Dr. Ales Hrdlička presented before the annual meeting of the American Medico-Psychological Association, 1899, the results of his

examination of the brain of an adult male Eskimo, a member of the party of six brought to New York in 1896 by Lieutenant Peary. In size and complexity of conformation the cerebrum indicated a degree of development equal to that of the average white person. The parts of the encephalon did not have the relative proportions that exist in the white brain. The frontal lobes were about equal in size to those of whites, while the portions posterior to the fissure of Rolando were considerably larger. The paper is illustrated by seven excellent plates.

In a reprint from the *Archives of Neurology and Psychopathology*, Vol. I, No. 4, 1898, we find a discussion by Dr. Hrdlička of the "Dimensions of the Normal Pituitary Fossa, or Sella Turcica, in the White and Negro Races, an anatomical study of fifty-seven normal skulls of white and sixteen normal skulls of colored individuals." Since marked enlargements of the pituitary body are of a pathogenic nature, it is considered desirable to determine the normal dimensions and the range of variation in its size. This can best be accomplished by measuring the pituitary fossa. The length, width, and depth of the fossa were measured, and a module derived similar to the skull module of Schmidt. The relation to the total size of the skull was obtained by multiplying this module by 1000 and dividing the result by the circumference of the skull, expressed in centimeters.

F. R.

GENERAL BIOLOGY.

Protoplasmic Streamings. — Martin Heidenhain[1] adds some very interesting observations to our knowledge of the remarkable phenomena of currents seen in so many vegetable cells. In the elongated cells of the hairs in the flowers of the pumpkin he studied especially the movements of the granules. In favorable specimens there are apparent gliding movements of the granules, even when the protoplasm seems quiet. Frequently, however, the protoplasm is actively moving in masses, producing those constant changes in the form and arrangement of the strands that join the central, nucleated region with the protoplasm lining the cell wall, that have been described by other observers. But even when there is, apparently, temporary rest of the protoplasm, the granules may move

[1] Einiges über die sogenannten Protoplasma-Strömungen, *Sitz.-Ber. Phys.-Med. Gesell. Wurzburg*, 1898.

along as if carried by a current; that they are not in a current of protoplasm seems demonstrated, the author thinks, by the fact that granules pass in different directions close to one another, and one may even advance against the "stream" or crowd of others going in an opposite direction. These same facts strengthen the author's belief that protoplasm is not a liquid.

The author explains these apparently automatic movements of the granules (and of the chlorophyll bodies) as due to contractility, not resident in the granule but in the adjacent protoplasm. He adopts the inotogmata hypothesis of Engelmann, and conceives fibrils made of living particles *temporarily* joined. Along those transitory fibrils waves of contraction proceed, and thus the adjacent, inert, dead granules are, in some way, forced along. The granules are moved along in temporary routes made by the contractile fibrils.

The basis for the assumption of such hypothetical fibrils is: (1) the existence of visible fibrils, (2) certain changes in optical value, and (3) waves of contraction seen under the microscope. The author agrees with Bütschli that the structure of the protoplasm in these cells is that of a foam; he sees striations and cross-connections in masses where shape and arrangement change in such wise that the existence of a foam seems to underlie the above appearances.

But in the structure lines, lamellæ he thinks them, he also sees long and short fibrils which are sometimes stationary, sometimes moving along like granules. These curious fibrils are soft and easily break up; they are, he maintains, in the walls of the alveoli, that is, between the vesicles of the foam structure. He supposes these fibrils are the remnants, or ruins, of hypothetical contractile lines of protoplasm which are no longer functional.

The changes in optical value spoken of are passages from bright to dark which are seen in the lamellæ, and interpreted as being coexistent with changes in the contractile material.

The waves of contraction seen are bendings in the usually straight lamellæ, or striations.

Whatever the nature of these remarkable interalveolar fibrils, their existence harmonizes the divergent views of Flemming and of Bütschli to the extent that a foam structure is found with actual fibrils between the alveoli; in this and in several other points the author's observations confirm some of the facts recorded for various animal cells by G. F. Andrews[1] and open a most suggestive field of research upon oft-tried material. E. A. A.

[1] *The Living Substance.* Boston, Ginn & Company, 1897.

ZOÖLOGY.

A New Practical Zoölogy.[1] — A new elementary text-book of practical zoölogy on the lines already made familiar by Huxley and Martin's *Elementary Biology* has been published under the joint authorship of the late T. J. Parker and W. N. Parker. The student finds an introduction to the principles of zoölogy through a study of the frog, which occupies somewhat more than a third of the volume. Then follow chapters on the amœba, hæmatococcus, infusorians, hydra, earthworm, crayfish, fresh-water mussel, amphioxus, dogfish, and rabbit. Many of these chapters include discussions of general zoölogical problems especially well illustrated by the particular animal under consideration; thus, under Infusoria, biogenesis and abiogenesis are discussed, and under Hydra and its allies, alternation of generations. The book is concluded with a chapter on the structure of the cell and its rôle in development, as illustrated by vertebrate embryology. There are numerous good illustrations, and the practical directions are such as are of real value. The volume forms an important contribution to the list of laboratory text-books. P.

Gogorza's List of the Vertebrate Animals of the Philippines. — In the *Annals of the Natural History Society of Madrid* for 1888, José Gogorza y González gives under the title of "Datos para la Fauna Filipina," a list of the vertebrate animals known from these islands. The list is based largely on the collections in the museum at Madrid, the collections of numerous Spanish engineers and explorers, notably Francisco Martinez, Carlos de Mazarredo, José Pérez Maeso, Domingo Sánchez, and Regino Garcia.

Thirty-five species of mammals are recorded: 156 of birds, 87 of reptiles, 10 of amphibians, and 292 of fishes. No new species are described in any group. The nomenclature of the fishes is not very modern, being apparently based solely on Günther's *Catalogue of the Fishes of the British Museum*. There is, however, evidence that the work has been conscientiously performed. All the species mentioned are ascribed to a definite locality, a fact which indicates that the paper is not at all a compilation, and that the collection on which it is based is a very rich one, though doubtless not including more than a third of the fishes actually visiting these islands. D. S. J.

[1] Parker, T. J., and Parker, W. N. *An Elementary Course of Practical Zoölogy*. xii + 608 pp., 156 illustrations. New York, The Macmillan Company, 1900.

Lungless Salamanders. — In the *Zoologischer Anzeiger*, Dr. Einar Lönnberg, of Upsala, has an interesting list of salamanders which have the lung rudimentary or wanting. The catalogue includes the results of his own work and that of Harris Wilder, Camerano, and Moore.

Salamanders may in this regard be divided into three classes: (1) those in which the lungs extend to the groin and are about 60 per cent of the length of the body. To this class belong certain Asiatic species of Diemictylus (Molge); (2) those in which the lungs extend only halfway from the axil to the groin, measuring 38–45 per cent of the length of the animal. To this class belong other species of Diemictylus, species of Salamandrella, Ranideus, and, among American species, *Ambystoma punctatum* and *A. microstomum*. Apparently the American species of Diemictylus (viridescens, torosus) have not been studied; (3) those without lungs or with merely a rudiment. In this class, among American species, belong the following: *Ambystoma opacum* (rudiment), *Aneideslug ubris*, *Plethodon cinercus*, *P. glutinosus*, *Spelerpes porphyriticus*, *S. ruber*, *S. longicauda*, *S. guttolineatus*, *S. bilineatus*, *Manculus quadridigitatus*, *Desmognathus fuscum*, *D. brimleyorum*, *D. nigrum*, and *D. achrophæum*. Other species of Spelerpes, with Leurognathus and Batrachoseps, are known to belong to this category, which probably includes all Plethodontidæ and Desmognathidæ.

"Camerano has rightly pointed out the importance of the lungs as a hydrostatic organ, and it seems quite possible that the great length of the lungs in many forms is an adaptation to aquatic life. But the lungless salamanders are not necessarily obliged to lead a terrestrial life, even if many of them do so; on the contrary, some of them are very positively aquatic in their habits." Such do not, however, as is the case with Diemictylus, remain suspended in the water, but crawl or wriggle at the bottom.

D. S. J.

The Egg of the Hagfish. — In the *Proceedings of the Natural History Society of Copenhagen*, Adolf Severin Jensen has a valuable account of the egg of the hagfish (*Myxine glutinosa*), entitled "Om Slimaalens Æg."

The egg of this singular creature was first described in 1859 by Allen Thompson. It has been noticed a few times since then, mostly from specimens taken in the stomachs of other fishes, but most who have written on the animal and its biology have never found a perfect egg.

The conclusion of Mr. Jensen's observations is that the hagfish fastens its egg by wiry, hair-like appendages to objects on the sea bottom. These appendages are fastened to either pole of the egg, which is oval in form. Jensen figures a dead stalk of Cellepora, to which four eggs are attached. He gives also several figures of the sucker-like anchors ("thread cells," or "spider cells"), each with two to four lobes in which the hairs which hold the egg terminate.

A species of hagfish (*Polistotrema stouti*), rather distantly related to Myxine, occurs on the Pacific coast, and is abundant in the Bay of Monterey, where various features of its structure have been studied by several workers in the Hopkins Seaside Laboratory, notably by Dr. G. C. Price, Dr. F. M. McFarland, Dr. C. W. Greene, Dr. Bashford Dean, Dr. Franz Döflein, and Dr. Howard Ayers. For a long time the egg of this species was unknown. At last the Chinese fishermen began to bring them in, saying that they got them by pressing the bodies of the females. Many of them were half decomposed when received. Later Dr. Dean and Dr. McFarland discovered that these eggs were not taken from the females at all, but from the stomachs of the males, which accounts for their half-digested condition. Nearly all the eggs of hagfish thus far found at Monterey are from the stomachs of male fishes.

Dr. Dean figures one individual in which the clumps of wiry filaments which hold the egg are caught in the encasing slime of an adult animal. The investigations of Mr. Jensen indicate that these eggs should be sought on the sea bottom attached to bryozoa or algæ.

Mr. Jensen notes that the Atlantic hagfish has no larval or Ammocœtes stage, such as the lamprey passes through, the young, of six centimeters, being similar to the grown fish. In this respect the California hagfish agrees with Myxine.

D. S. J.

Waite's Fishes of the Thetis Expedition. — In the *Memoirs of the Australian Museum*, Mr. Edgar R. Waite gives an account of the fishes taken by the trawling expedition of H. M. S. C. *Thetis*, Capt. C. P. Hildebrand, in the waters about Port Jackson. The collection obtained, of which a brief preliminary report has been already published, is a very interesting one, and the paper is one of the most valuable contributions yet made to the natural history of Australia. The excellent plates are to be especially commended.

One hundred and seven species were obtained by the *Thetis*, nine of which are new. These are: *Dasyatis thetidis*, *Chimæra orgilbyi*, *Anthias pulchellus*, *Monacanthus setosus*, *Sebastes* (rather Sebastodes)

thetidis, *Lepidotrigla modesta*, *Parapercis ocularis*, *Histiopterus farnelli*, and *Paralichthys tenuirastrum*. A new name, *var. elevatus*, is proposed for the Australian representative of *Macrorhamphosus scolopax*. Two new genera, Paratrachichtys (trailli) and Pterygotrigla (polyommata, in place of Hoplonotus, preoccupied), are defined.

Perhaps the most interesting of the new forms is *Sebastodes thetidis*. That genus, now known to be represented by about fifty species off the coast of California and a dozen more in Japan, and a few off Chili, has its range thus extended southward to Australia. The new species is one of the extremes of the type, somewhat allied to *S. nigrocinctus*, but still more spinous about the head. In the present system it would be the type of a distinct subgenus, or possibly genus, standing at the very opposite extreme of the series from *Sebastodes paucispinis*, the original type of the genus.

The nomenclature and sequence adopted by Mr. Waite are thoroughly modern and in accordance with the law of priority. We may perhaps question the identity of the Australian horse mackerel with *Sarda chilensis* of Chili, or of the kingfish with *Lenola lalaudi* of Brazil. These identifications have been accepted by authors, the present writer among the number, but it seems better not to regard a species as cosmopolitan until actual comparison has shown it to be so. In most cases of this kind comparison of adequate material will show specific difference.

It is to be hoped that this very acceptable piece of work will be followed by many others until the natural history of Australia is thoroughly known.

D. S. J.

Smitt on Lycodes. — In *Annals and Magazine of Natural History*, Professor F. A. Smitt, of Stockholm, has a brief review of the species of Lycodes of the North Atlantic. He maintains that all specimens known to him are referable to four species. *Lycodes reticulatus*, vahlii, sarsii, and muræna. *Lycodes perspicillum* (*L. rossii*), he thinks, is the young of *L. reticulatus*, which is probably correct. *Lycodes frigidus* is a "mixture of sterile or deformed specimens" of vahlii and reticulatus. *Lycodes gracilis* is a northern variety of *L. vahlii*, with the head shorter (less than 22 per cent of total length; more than 22 per cent in typical vahlii). He suggests that *Lycodes muræna* is probably "a local or evolutional form of *Lycodes sarsii*." But that is about all that one could claim for any of the species in a group like Lycodes, in which the species are all closely related and vary much with conditions.

The characters of position of lateral line and numbers of pectoral rays used by Jordan and Evermann as a clue in this group are not noted by Dr. Smitt. D. S. J.

Abbott on Chilean Fishes. — Mr. James F. Abbott, a graduate student of Stanford University, now teacher in a Japanese academy at Otsu, gives in the *Proceedings* of the Academy at Philadelphia notes on fishes collected at Valparaiso by Rear-Admiral Beardslee, U. S. N. Among these is a species of *Hippoglossina macrops*, which was originally, perhaps, incorrectly recorded as from Mazatlan. There is also a new species of Sebastodes, allied to *S. oculatus* and *S. darwini*. To this Abbott gives the name of *Sebastodes jenynsi*.

D. S. J.

Moreno on the Olfactory Nerves of Fishes. — In the *Annals of the Natural History Society of Madrid*, José Madrid Moreno gives an account of his studies of the olfactory nerves of fishes carried on in the laboratory at Naples. The anatomy of these nerves and their terminations is described in species of Scylliorhinus, Catulus, Scorpæna, Raja, Pagellus, and Serranus. D. S. J.

California Water Birds — No. IV (*Proc. Cal. Acad. Sci. Zoöl.*, Vol. II, No. 3, 1900). — Mr. Leverett M. Loomis gives us the latest results of his studies on the migration of sea birds on the western coast of North America. The bulk of the paper consists of a detailed record of observations made at Monterey Bay and vicinity from Sept. 18, 1896, to Nov. 14 of the same year; but the portion of most interest, at least to the general zoölogist, is the discussion of the data obtained, and the conclusions drawn.

The following extracts will indicate not merely the results arrived at by the author, but as well the scope of his studies in this difficult but fascinating field; for the evidence on which the conclusions rest, the paper itself must be consulted.

"These investigations seem to prove (1) that the Shearwaters off Monterey find their position and shape their course by the landmarks; (2) that birds do not possess a mysterious superhuman faculty for determining direction, else the Shearwaters would not have been bewildered in the fog."

"It seems reasonable to conclude that young birds in the journey from their birthplace to the winter home of the species are dependent upon the guidance of the old birds who know the way, because they have traveled it."

"To sum up the whole matter in a single sentence: It is held that bird migration is a habit evolved by education and inheritance which owe their origin and perpetuation to winter with its failure of food."

W. E. R.

Ovogenesis in Tunicates. — Dr. F. W. Bancroft has published (*Bulletin of the Mus. of Comp. Zoöl.*, Vol. XXXV, No. 4, 1899) an extended account of his studies on the ovogenesis of *Distaplia occidentalis.*

In general, the development of the gonads and their ducts resembles that found in Perephora, Clavelina, and Ciona.

The most significant difference consists in the fact that the fundament of the ovotestis is present in the youngest stages in Distaplia, whereas in the other species it appears quite late in ontogeny.

To the question which type of ovary is more primitive, that represented by Clavelina, where there are two separate germinative epithelia, or that found in Distaplia with but a single such epithelium, the author is inclined to give the distinction to the Distaplia type, since here it occurs in a smaller and simpler species, and is itself simpler.

Dr. Bancroft goes at length into the question of the origin and fate of the test cells, discussing the whole matter in the light of the more recent statements by Davidoff and Salensky, based on their observations on *Distaplia magnilarva.* He does not confirm the results of these authors, and as his studies pertained to a species very closely related to the one studied by them; and, furthermore, as he had the opportunity, through the great courtesy of Professor Salensky, to examine slides of *D. magnilarva*, it would seem that his critical findings should be conclusive on this much discussed problem.

The function of these cells, the author believes, is to furnish nutriment to the growing ovum. He concludes that they are particularly active in this capacity in the early stages of the growth of the ovum, while the nucleus exerts its principal activity in the later stages in converting this nutritive material into yolk.

The germinative vesicle diminishes in size gradually and continuously with the increase in quantity of yolk in the ovum.

W. E. R.

Reproduction of Amœba. — In addition to the common and recurring bipartite division of *Amœba proteus*, Scheel[1] has described a

[1] Scheel, C. Beiträge zur Fortpflanzung der Amœben, *Festschrift zum siebenzigsten Geburtstag von Carl von Kupffer*, pp. 569–580, Pl. LI. Jena, 1899.

method of sporulation, or multiple reproduction, which takes place within a cyst formed by the animal itself. This cyst is thick-walled, spherical, and transparent, and, although without stalk or adhesive organ of any sort, it regularly sticks fast to small objects in the water, being found singly or in groups on sticks or stones. The series of changes were not observed in full, but the nucleus of the amœba is reduced by a series of direct divisions into a large number of daughter-nuclei. When this number has reached some five or six hundred the body of the amœba divides into as many independent daughter-individuals, and these are set free by the gradual decay and bursting of the cyst wall. A flagellate stage does not occur in *Amœba proteus*, but the spores enter directly upon the amœboid condition.

The causes of the multiple division in the encysted condition were not determined. The process is not related to sexual reproduction and apparently does not occur at regular intervals. Experiments by starvation, excess of food, evaporation of the water, and by transferring the animals to water from other localities, *i.e.*, by changed conditions of existence to bring the amœbas to encystment and sporulation, were uniformly without success. H. B. W.

Arctic Deep-Sea Fauna. — One of the most important results of recent Arctic exploration is the discovery of a true deep-sea fauna. An address delivered recently to the German Zoölogical Society by Dr. Schaudinn,[1] on the expedition made in 1898 by Drs. F. Schaudinn and F. Roemer to Spitzbergen, contains a preliminary report on this fauna.

This expedition set out to make collections in the Spitzbergen Sea, and successfully tried to reach the deep Arctic basin discovered by Nansen. This deep, called by Schaudinn the "Nansen Rinne," was reached north of Spitzbergen in 81° 32′, and a number of deep-sea dredgings were made. A true deep-sea fauna was discovered entirely different from the Arctic fauna of the shallow sea surrounding Spitzbergen (and from the other Arctic faunas hitherto known). Its most striking feature is the presence of an abundance of Hexactinellid sponges, a group never found previously in the Arctic regions, all of them belonging to new genera. These sponges are so plentiful that their remains form a very characteristic deposit on the bottom, composed of the spicules of the dead sponges closely connected and densely interwoven, so as to form a fine network, the meshes of

[1] Schaudinn, F. *Verh. Deutsch. Zool. Gesellsch.* (1899), pp. 227 ff.

which are filled with mud ; after washing out the mud, about one-third of the volume remains as a glittering mass ("Glaswolle").

A detailed report on the peculiarities of this deep-sea fauna will be given in a separate work entitled *Fauna Arctica*, and will be, no doubt, one of the most interesting additions to our knowledge of the Arctic faunas. A. E. O.

Arctic Marine Animals. — The material collected by the Princeton Expedition to North Greenland in 1899 has been sorted out, and part of it has been identified. It proves to be the largest collection of Arctic marine life ever made in the neighborhood of Inglefield Gulf and Smith Sound. Of the animals reported by former expeditions (Hayes, Nares, Peary Expedition of 1894), nearly every species is represented in the collection, while many additional species were taken which have not yet been recorded from these parts.

The chief value of this collection lies on the zoögeographical side, adding new localities to the known range of Arctic forms from parts hitherto almost unknown. These localities, situated so far north (76–79°), will be very valuable in the construction of a connection between many species now known from the Atlantic and Pacific parts of the Arctic seas. Some species seem to be truly circumpolar in distribution, while in others the connection seems to be interrupted. For the establishment of such cases an investigation of the fauna of this region as well as that of the northern coast of Siberia is necessary, and the collections of the Princeton Expedition to North Greenland, when published, will, in this respect, add considerably to our knowledge. A. E. O.

Notes. — Dr. Thiele reports in *Fauna Arctica* a new solenogaster, *Proneomenia thulensis*, found by the German Arctic Expedition of 1898. It is characterized by a radula with many small teeth and by a multifid receptaculum.

In the Munich *Sitzungsberichte* Mr. A. M. Przesmycki reports his success in staining the nucleus of living Opalina and Nyctotherus with neutral red. The chromatin elements show the deeper color, and the phases of nuclear division may be watched in the living organism.

Text-books of zoölogy have made the statement that the mouth in the Infusoria is formed by the simple division of the parental organ. In the Heidelberg *Verhandlungen* Dr. A. Schuberg describes the origin of the peristomal region of *Euplotes patella* as a series of

extensive and complicated growth processes in which no simple plane of division can be recognized.

An interesting prorhynchid turbellarian from deep wells in New Zealand has been described by Haswell (*Quart. Journ. Micr. Sci.*, Vol. XL, pp. 631–645, Pl. XLVIII). It is most closely related to the Prorhynchidæ and not to the Alloiocœla, as at first believed. The complicated pharynx, the lateral vitello-germarium, and the unpaired lateral testis are among the important peculiar structural features of this form which the author includes provisionally in the genus Prorhynchus.

In an extended study of the morphology and physiology of *Euglena gracilis*, Zumstein (Inaugural-Dissert., Basel, 1899) shows that this species does not manifest anything of an animal method of life. Its nutrition may be purely holophytic, purely saprophytic, or both combined, but thrives best under the latter. The colorless variety of the species may be transformed into the green, or *vice versa*, with corresponding change in manner of nutrition.

The frequency of trematodes has been studied by Hausmann (*Centralbl. f. Bakt. u. Par.*, I. Abth., Bd. XXVI, pp. 447–453) in birds from Baden and the vicinity of Basel. The percentage of infection found was, Grallatores 29, Raptatores 26, Natatores 25, Corvidæ 24, which is from three to six times as large as numbers previously listed from birds.

Number IX of the third volume of the *American Journal of Physiology* contains the following articles: "On the Reactions of Chilomonas to Organic Acids," by H. S. Jennings; "Notes on the Individual Psychophysiology of the Crayfish," by G. V. N. Dearborn; "On the Artificial Production of Normal Larvæ from the Unfertilized Egg of the Sea Urchin," by J. Loeb; and "On the Maximum Production of Hippuric Acid in Rabbits," by W. H. Parker and G. Lusk.

In a reply (*Archiv f. die ges. Physiologie*, Bd. LXXIX, 1900) to a criticism of his paper on the psychic qualities of ants and bees, Albert Bethe tells us that the chief error in his work is that he did not distinguish clearly enough between objective expression and subjective "Empfindung" in our own psychological processes. He says that he agrees with Uexküll that the question concerning the Psyche of animals does not belong to the realm of exact science, and he declares that he is ever willing to discuss the question

whether or no ants and bees have the power to purposefully modify their acts (Modificationen vermögen besitzen), and whether a "Remanenz" of a stimulus is possible in them. But whether they possess a psychical quality or not, he will not discuss, since the objective expressions of animals and the causes of these are all that legitimately belong to biological research.

W. E. R.

A supplementary part has been issued to Vol. XV of the *Journal of Morphology* and contains the following articles: "On Protoplasmic Structure in the Eggs of Echinoderms and some other Animals," by E. B. Wilson; "Studies upon the Early History of the Ascidian Egg," by H. E. Crampton; "The Spermatogenesis of Amphiuma," by J. H. McGregor; "The Calciferous Glands of the Earthworm, with Appendix on the Circulation," by N. R. Harrington; "The Changes in the Structure of the Pancreas Cell," by A. Mathews; and "The Spermatogenesis of Anasa tristis," by F. C. Paulmier. The supplement has a paging of its own, but is unaccompanied by a table of contents or title page.

BOTANY.

Phenological Observations in Canada. — Mr. A. H. Mackay[1] gives an account of some interesting phenological observations made in Canada during the seven years 1892 to 1898. This was one of the lines of work undertaken by the Botanical Club of Canada, and from nine to nineteen reports were received each year, giving more or less completely the time of the appearance of leaves, flowers, and fruits and the migration of birds. The author calls attention to the many difficulties of obtaining complete and accurate records; for example, the more rare species may easily escape notice until they have been in flower for some time. Again, some individual plants are earlier than others in the same locality, and in the same individuals certain branches are earlier than others, hence the records were made to include "first appearance" and "becoming common." A phenological date is defined as "a sort of mathematical function of variables," which is influenced by variations in temperature, of atmospheric pressure, sunshine, precipitation, together with the local constants, latitude, elevation, slope, proximity of bodies of water, and character of soil. The rapidity with which a season advances,

[1] *Canadian Record of Science*, vol. viii, pp. 71–84, 1900.

therefore, is governed "by the varying balance of the meteorological conditions affecting the organisms." A table is given of twenty objects most commonly observed, showing the average date for each of the seven years. From these the normal date or phenochron of each species is computed, together with the phenological norm or phenochron of the entire list for each year. Other tables are given of objects selected from different counties and provinces. If observers are symmetrically placed over a county, are competent and careful, and put the same interpretation on what constitutes "first appearance" and "becoming common," the averages would give phenological norms for the comparison of a very important character of the country with that of another, and more especially the comparison of one season with another in the same country, which, after a series of years, would contribute to the solution of the problem of secular variation of climate.

In 1897 the idea was extensively taken up in the schools of Nova Scotia as a part of the prescribed course in nature study, the pupils themselves making the observations under the guidance of the teachers. Hundreds of reports were sent in from as many school districts. It is believed to be a convenient means for the stimulation of pupils in observing all natural phenomena while going to and from school.

H. C. IRISH.

King's Irrigation and Drainage. — The high standard of excellence already established in the Rural Science Series under the editorship of Professor L. H. Bailey is fully maintained in the latest volume.[1] Although this volume is quite complete in itself, it may be regarded, in a way, as supplementary to Professor King's work on soils, with which the series began. Like that, the present work is addressed primarily to practical farmers and agricultural students, but at the same time it contains much of value to all interested in the nutrition of plants.

In an introduction of sixty-five pages the author discusses with considerable fullness the importance of water to the plant, and details some noteworthy experiments carried on by him at the University of Wisconsin to determine the quantity of water used by cultivated plants in coming to perfection under ordinary field conditions. The data thus obtained for various crops figure in impor-

[1] King, F. H. *Irrigation and Drainage:* principles and practice of their cultured phases. New York, The Macmillan Company, 1899. 12mo, xxii + 502 pp., 163 illustrations.

tant ways throughout the book. Part I, on Irrigation Culture, opens with an account, historically developed, of The Extent and Geographical Range of Irrigation. Then follow chapters on The Conditions which make Irrigation Imperative, Desirable or Unnecessary, The Extent to which Tillage may take the Place of Irrigation, and The Increase of Yield due to Irrigation in Humid Climates; then several chapters regarding the practical management of water under various conditions, and finally a chapter on Sewage Irrigation. Part II deals with the principles and practice of Farm Drainage.

In almost every chapter one finds an immense amount of information clearly displayed in tabular form and often representing the results of the author's experimental contributions to the subject. Then, too, one gains confidence in the author's general statements from the evident fact that they are based upon wide personal observation of irrigation and drainage practice, both in this country and in Europe. The author champions no pet theory; he lets facts speak for themselves and lead the way to broad principles of practical value.

The illustrations, largely reproductions from photographs, are, for the most part, of unusual excellence, and so reproduced as to show clearly the features intended to be seen.

F. L. S.

Trimen's Flora of Ceylon.[1] — Seven years ago, Professor Trimen, then director of the Royal Botanic Gardens of Ceylon, began the publication of a manual of the plants of that important island, which has now been brought to a conclusion in the fifth "part," or volume. The author lived to bring out only the first three volumes, and the other two have been seen through the press by Sir Joseph Hooker. To the concluding volume are appended a key to the orders, genera, and aberrant species of Ceylon flowering plants, with diagnostic characters of the orders; a chapter on the forests and waste lands of Ceylon, by A. F. Broun; a chapter on the distribution of the rainfall in Ceylon, by F. Lewis; a history of Ceylon botany, by G. S. Boulger; a table of corrections; and comprehensive indices to the entire work.

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[1] *A Hand-Book to the Flora of Ceylon.* Containing descriptions of all the species of flowering plants indigenous to the island, and notes on their history, distribution, and uses. By Henry Trimen. Continued by Sir J. D. Hooker. London, Dulau & Co., 1893–1900. 5 vols., 8vo.

Nuclear Phenomena in Ustilagineæ. — Contributions such as Professor Harper presents[1] have been few, but are much needed to explain this class of plants. He studied, in particular, the germination, growth, divisions, and fusions of *Ustilago antherarum* and *U. Scabiosæ*. He finds that in fusions of conidia, which are apparently caused by chemotactic stimuli, no nuclear changes take place, yet the cytoplasmic union of the cells causes them to increase in size, and gives them power to resist unfavorable conditions. It may be a primitive or degenerate sexual union.

J. B. S. NORTON.

Cell Division in Sporangia and Asci.[2] — Dr. Harper has contributed another very valuable investigation upon the morphology of the structures named. Among the Phycomycetes he has studied spore formation in sporangia of Synchitrium, Pilobolus, and Sporodinia, and for comparison, ascospore formation in *Lachnea scutellata* among the Ascomycetes, in which he was able to find stages undiscernible in his previous work on Peziza and Erysiphe.

In Synchitrium he regards the uninucleated cell as the vegetative body of the plant, the supervening multinucleate condition constituting, in his view, a sporangium rather than a thallus body. Cleavage by invagination of the plasma membrane follows this multinucleation, the contents of the "sporangium" being segmented, from without inward, into irregular plasma masses containing numerous nuclei. This cleavage resembles what is seen in some insect eggs. The segmentation of the protoplasm does not occur by repeated bipartitions or by the formation of walls, simultaneously, about the several nuclei. Orientation with respect to the nuclei is not evident at first, but becomes apparent later, in the final subdivision of the contents of the sporangium into uninucleate plasma segments. A shrinkage then occurs, followed by increase in size of these "protospores" and the subsequent repeated division of their single nuclei, to form from eight to twelve or more in a single "protospore." The number of them is not definite as in the ascus, but seems to depend, according to Harper, on the individual conditions of nutrition in the different "protospores."

Substantially the same cleavage process of spore formation was observed in three species of Pilobolus and in Sporodinia. There is nothing in the process of spore formation described in the Phycomy-

[1] Harper, R. C. Nuclear Phenomena in Certain Stages in the Development of the Smuts, *Trans. Wis. Acad. Sci.*, vol. xii, pp. 475–498, Pls. VIII, IX. October, 1899.

[2] R. A. Harper, in *Annals of Botany*, December, 1899.

cetes which at all resembles the free cell formation in the ascus, where the spores are cut out of the ascus plasm by the revolution of the aster rays. In the Phycomycetes we have isolation of the "protospores" by successive irregular segmentations, not simultaneous, but progressive. "This progressive segmentation has no parallel in the asci, where from the start a single nucleus forms the center for the formation of each daughter-cell" (p. 517). Harper finds it possible to connect the cleavage processes of the Phycomycetes with other cases of division by constriction, as in cell division in Cladophora, or in the abstriction of conidia in Erysiphe, as described by him, but he finds no connecting link between this general process of spore delimitation and free cell formation in the ascus. This stands as opposed to the older view of Brefeld that the ascus merely represents an evolution out of the ancestral sporangium, from an indefinite to a definite number of spores of definite size and form. Moreover, in the origin and character of the "epiplasm," regarded as a distinctive feature of the ascus, and that of the "episporal slime" of the sporangium, Harper finds no connection whatever. A possible origin of the processes seen in the ascus is suggested tentatively in such phenomena as Strasburger described (*Zellbildung und Zelltheilung*) for swarm-spore formation in Œdogonium. This, however, the author has not as yet been able to confirm by personal investigation.

The general conclusion is that the Ascomycetes cannot have arisen from the Phycomycetes, — the ascus seems to stand by itself as a peculiar structure, whose origin is at present in obscurity, — and, finally, the author's researches, together with those of Thaxter on the Laboulbeniaceæ, seem to point very strongly to a multiple algal origin of the fungi and the subsequent independent evolution of certain forms of spore production by different groups.

H. F. Roberts.

Notes. — The Cactaceæ of the Galapagos Islands are passed in review, by Dr. Albert Weber, in the *Bulletin* of the Paris Museum for 1899, and four species are recognized, of which two, pertaining to the genus Cereus, are characterized as new, while the other two, belonging to the genus Opuntia, were described and named in 1898.

A. Purpus, of the Darmstadt Botanical Garden, publishes an article on North American cacti which have proved hardy in Germany, in *Die Gartenwelt* of January 7. Several reproductions from photographs represent the species referred to.

Dr. Schumann contributes an article on the art of collecting cacti to the *Notizblatt* of the Berlin Botanical Garden of December 29.

Parsonsia paddisoni, a new apocynaceous plant yielding large edible tubers, is described by R. T. Baker in No. 95 of the *Proceedings of the Linnæan Society of New South Wales*, which contains several other papers of botanical interest.

The botany of New Zealand receives fourteen contributions, covering various groups of flowering plants and cryptogams, and abundantly illustrated, in the twenty-third volume of the *Transactions and Proceedings of the New Zealand Institute*, the frontispiece for which is a portrait of the veteran botanist Colenso.

A study of the seed dispersal of *Pinus sylvestris* and *Betula alba*, the results of which are published by Robert Smith in the *Annals of Scottish Natural History* for January, shows that the seeds of the former have been effectively carried by the wind to a distance of 886 yards, and of the latter to a distance of 489 yards, from the parent trees.

The most imposing brochure of the first volume of the *Proceedings of the Washington Academy of Sciences*, the publication of which has just been concluded, and the form, typography, illustration, and make-up of which constitute a model worthy of the study of all publishing bodies, is devoted to a description of a new genus and twenty new species of fossil cycadean trunks from the Jurassic of Wyoming, by Professor Lester F. Ward.

The geographical distribution of *Solanum carolinense*, *Tribulus terrestris*, and *T. maximus*, is discussed by Pammel in *Bulletin No. 42* of the Iowa Agricultural College.

The lime content of the soil, which plays an important rôle in the growth of certain plants, has been carefully worked out about Cognac by Guillon, whose results, with especial reference to viticulture, are given in the *Revue de Viticulture* for January 6, with the aid of a colored map.

The "Report on the Progress of Pharmacy," in the *Proceedings of the American Pharmaceutical Association* for 1899, contains a large amount of information, tabulated by plant families, which is not likely to be found so readily elsewhere by botanical students.

The results of all available American chemical analyses of nuts, and a discussion of the value of nuts as food for man, are contained in *Bulletin No. 54* of the Maine Agricultural Experiment Station.

Farmers' Bulletin No. 108 of the Department of Agriculture at Washington deals with saltbushes, — plants adapted to salt or alkaline regions, — and is written by Dr. P. B. Kennedy.

The *Bulletin de l'Herbier Boissier*, under the editorial care of M. Autran, curator of the herbarium which was founded by Boissier and is maintained near Geneva by M. Barbey, suspends publication on the conclusion of Vol. VII. It is to be continued by a series of octavo *Mémoires*, the first of which, a continuation of Professor Schinz's "Pflanzenwelt Deutsch-Südwest-Afrikas," was issued on Jan. 15, 1900.

An interesting account of the one-time London Botanic Garden, established by Salisbury in 1807, and the later history of which seems to have passed into oblivion, is given by W. Roberts in the *Gardeners' Chronicle* of February 3.

The *Gardeners' Chronicle* of February 24 contains a figure of the monument to David Douglas in the parish churchyard at Scone and a transcript of the inscription which it bears, as well as a portrait and short biographical sketch of this interesting man, of whom it has been said that no other collector has ever reaped such a harvest in America, or associated his name with so many useful plants, and that nobody, not even Fortune, has conferred so much honor on the Royal Horticultural Society, and so much benefit to horticulture in general as regards the importation of plants.

A good portrait of Professor A. S. Hitchcock, who is this year Director (or President) of the Académie Internationale de Géographie Botanique, is issued with the March *Bulletin* of that organization.

The first fascicle of Vol. XVII of *La Cellule* has as frontispiece a portrait of the late Professor J. B. Carnoy, and contains the address delivered at his funeral by Dean Gilson of the University of Louvain.

Portraits of the Tulasne brothers form the frontispiece to Vol. XVI of the *Bulletin* of the Société Mycologique de France.

Dr. Willis, Director of the Royal Botanic Gardens at Peredeniya, Ceylon, calls attention to the new research station of that important establishment, in the *Botanical Gazette* for March. The facilities of the garden are freely offered to competent investigators.

The March number of the *Journal of the New York Botanical Garden* contains an interesting account of the herbarium of the New York Garden and of its new home.

The genus Cratægus receives a further accession of eleven new species for the Eastern States in a contribution by W. W. Ashe to the *Journal of the Elisha Mitchell Scientific Society*, published in February.

The results of an experimental study by Henseval of abrine, the highly toxic albuminoid of *Abrus precatorius*, are published in the current volume of *La Cellule.*

Cereus mojavensis, one of our interesting desert cacti, is figured in the *Botanical Magazine* for March.

A revision of the species of Plantago commonly referred to *P. Patagonica*, by E. L. Morris, appears in the *Bulletin of the Torrey Botanical Club* for March, and apparently contains the results of careful study.

The North-American species of Chætochloa are revised by Scribner and Merrill in *Bulletin No. 21* of the Division of Agrostology of the United States Department of Agriculture.

In a note in the *Journal of Botany* for February, Dr. Masters states that while the *Glyptostrobus pendulus* of English gardens is merely a variety of *Taxodium distichum*, there is a true Glyptostrobus, which, while in garden specimens that have not yet reached the fruiting age cannot be separated from Taxodium, is yet amply distinct when fruiting, in its elongated (not peltate), cone-scaled and evidently winged seeds.

A supposed bigeneric hybrid between *Cystopteris fragilis* and *Asplenium Trichomanes* is described from the Jura by Parmentier in the *Bulletin de l'Académie Internationale de Géographie Botanique* for February.

A catalogue of the flora of Montana and the Yellowstone National Park, by Dr. Rydberg, constitutes the first volume of the *Memoirs of the New York Botanical Garden* — a volume of nearly 500 pages, issued in February, 1900.

An analytical list of the plants of Rovereto is published by Professor Stefani in Vol. V of the *Atti della I. R. Accademia . . . degli Agiati*, and should be of use to visitors to the region of the Adriatic.

A botanical bibliography of the Argentine Republic is reprinted by F. Kurtz from Vol. XVI of the *Boletin de la Academia Nacional de Ciencias de Córdoba.*

Among the applications of photography now being presented in *The Process Photogram* of London, that of recording tree forms, in the March number, is of interest to botanists, since, as the editor says, it is truly "a very difficult task to give a photographic account of a tree."

PETROGRAPHY.

The Petrographical Province of Essex County, Mass. — A very careful and critical study of the igneous rocks of Essex County, Mass., is given us by Washington[1] in a recent series of papers in the *Journal of Geology*. The district "is characterized as one of rocks which are more acid or more basic than normal, high in alkalis, with Na_2O predominating over K_2O, high in iron oxides, especially FeO, rather high in Al_2O_3, and low in MgO and CaO." The rock types recognized are granites, quartz-syenites, diorites, essexites, gabbros, rhyolites, and the dike rocks, aplite, microgranite, diabase, paisanite, and camptonites. The essexites embrace also pulaskites and litchfieldites, characterized by the presence of albite, nepheline, ægirite, and alkaline amphiboles.

All these rocks are regarded as differential phases of a laccolitic mass, with a composition approximating that of an acid diorite.

The first differentiation of this magma is thought to have given rise to the granites, syenites, diorites, and the granito-diorite dikes, and a further local differentiation of the basic forms to foyaites, essexites, and paisanite-tinguaite dikes.

Each of the rock types occurring in the district is carefully described, and of each a chemical analysis is given. The work is thorough. As the result of the paper, Essex County becomes one of the best known petrographical provinces in the country.

The two most interesting dike rocks[2] of the district are a glaucophane-sölvsbergite containing cordierite, and an analcite-tinguaite. Analyses of these two rocks follow:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	P_2O_5	Ign.
64.28	.50	15.97	2.91	3.18	.03	.85	7.28	5.07		.08	.20 = 100.33
56.75	.30	20.69	3.52	.59	.11	.37	11.45	2.90	.04 Cl = .28		3.18 = 99.92

Nepheline-Syenites. — The corundum-bearing nepheline-syenites of Ontario are of such economic interest that the Canadian official

[1] *Journ. of Geol.*, vol. vi, p. 787, and vol. vii, pp. 53, 105, 284, and 463.
[2] *Amer. Journ. Sci.*, vol. vi, 1898, p. 176.

geologists have recently carefully examined them. Coleman [1] describes an exposure on the New York branch of Madawaska River, in Dungannon township, as a light and gray banded rock cut by a pegmatite dike composed of large crystals of nepheline and muscovite. In the syenite are nepheline, albite, oligoclase, labradorite, orthoclase microcline-biotite, scapolite, calcite, muscovite, and occasionally augite and apatite. Corundum is also present, as small grains and large crystals usually associated with muscovite. Specimens obtained from exposures in other portions of Dungannon and neighboring townships present variations from the rock referred to above, but they are not of special significance.

In one case, however, a medium-grained white rock from Methuen, Peterboro County, consists essentially of a plagioclase, more acid than the plagioclase of the anorthosites.

The corundum in these rocks is thought to represent the excess of Al_2O_3 that existed in a magma supersaturated with alumina, but not saturated with silica.

Miller [2] outlines the situation of three belts of the corundiferous rocks. These rocks, like those referred to by Coleman, are syenites, nepheline-syenites, and an anorthosite. The last-named rock was analyzed, with this result:

SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	CO_2	Tot.
26.24	29.85	1.30	2.12	16.24	2.41	1.98	.18	1.03	=101.35

Its feldspar has the formula Ab_1, An_4, *i.e.*, it is a bytownite. The rock is from the Seine River.

Another occurrence of nepheline syenite in New Jersey is added by Ransome [3] to those already known in the State. The rock forms a portion of the trap mass of Mt. Gilboa, near Brookville, which is intrusive in Triassic beds. The constituents of the syenite are: orthoclase, anorthoclase, and other feldspars, nepheline, hornblende, ægirine, biotite, cancrinite, muscovite, analcite, natrolite, apatite, fluorite, and calcite, the last six named, with the exception of apatite, being secondary. An analysis gave:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	BaO	MgO	K_2O	Na_2O	H_2O	F
54.68	.79	21.63	2.22	2.00	2.86	.05	1.25	4.58	7.03	2.15	.22

SO_3	P_2O_5	Total	Less O = F	
.07	.28	99.81 —	.09	=99.72

[1] *Journ. of Geol.*, vol. vii, 1899, p. 437.
[2] *Amer. Geol.*, vol. xxiv, 1899, p. 276.
[3] *Amer. Journ. Sci.*, vol. viii, p. 417.

With this syenite are also associated a biotite and a hornblende-syenite and a hornblende-granite. The major portion of the trap mass is a fine-grained hypersthene-gabbro. The relation of the syenites to the trap could not be discovered.

Notes. — The granite-gneiss near Middletown, on the Connecticut River, is, according to Westgate,[1] an igneous rock. The rock is a biotite gneiss, often containing eyes of feldspar consisting of cores of single orthoclase crystals enclosing grains of other feldspars, and sometimes surrounded by peripheral zones of a granular feldspar.

A second series of analyses of Italian volcanic rocks is presented by Washington.[2] Among them is an analysis of ciminite from La Colonetta, on the south slope of Monte Cimino; one of the "mica-trachyte," or selagite, from Monte Catini, Tuscany; one of an andesite from Radicofani, Tuscany, and one of the well-known leucitite of Capo di Bove. The analyses of the ciminite (I), the selagite (II), and the leucitite (III), follow:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	BaO	Na_2O	K_2O	H_2O	Tot.
57.31	.40	14.71	1.21	4.37	7.80	6.90		1.35	6.38	.18	= 100.61
56.39	2.07	12.88	2.36	3.54	7.83	4.06		1.30	7.84	1.33	= 99.60
45.99	.37	17.12	4.17	5.38	5.30	10.47	.25	2.18	8.97	.45	= 100.65

The ciminite analysis differs from the original analysis of Washington's type rock in showing less Al_2O_3 and more MgO. The difference in the two analyses is explained as due to incomplete separation of the two oxides in the earlier analysis. The selagite appears to be a minette-like form of ciminite, differing from the latter in possessing biotite in place of olivine and orthoclase.

An excellent description of the titaniferous iron ores of the Adirondacks appears from the pen of J. F. Kemp.[3] The ores are shown to contain small quantities of hypersthene, augite, plagioclase, and many of the other constituents of gabbros. From their close association with rocks of this class, the author regards the ores as differentiation products of their magmas, in the same way that the titaniferous ores of Minnesota, of Sweden and Norway, and of other places are believed to be varietal phases of a similar magma. Incidentally, the paper describes a few gabbros and anorthosites from near Lake Sandford, in Newcomb township.

[1] *Journ. of Geol.*, vol. vii, 1899, p. 638.
[2] *Amer. Journ. Sci.*, vol. ix, 1900, p. 44.
[3] *Nineteenth Ann. Rept. U. S. Geol. Surv.*, Pt. iii, p. 377.

PUBLICATIONS RECEIVED.

(The regular exchanges of the *American Naturalist* are not included.)

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